

**A COMPLETE TEXT ON GENERAL
AND SYSTEMIC ANATOMY**

Essentials of CAPRINE ANATOMY

Compiled By

MUHAMMAD SAJJAD HUSSAIN
Student of DVM (2007-ag-1638)

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**Faculty of Veterinary Science
University of Agriculture
Faisalabad**

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Chapter 1

INTRODUCTION TO ANATOMY

Outline

- **What's Anatomy?**
- **Functions of Anatomy**
- **Divisions of Anatomy**
- **Methods to Study Anatomy**
 - **Systemic Study**
Division of systemic anatomy
 - **Topographic Study**
Topographic terms
- **Planes of the body**
- **Recumbency Positions**
- **Medical Terms for various species**
- **Common Animal Terms**

(ANA—apart, TOMY— to cut)

A **NATOMY** is that branch of biological sciences which deals with the structure and form of organisms. It includes the study of shape, weight, color, texture, and relative position of various organs and tissues of the organisms when they are in a state of normal health.

FUNCTIONS OF ANATOMY

The anatomical knowledge helps a veterinarian, in the discharge of his multifarious duties, in many ways. More important functions of anatomy are:

1. It gives an idea about the form, shape, structure and relative position of various organs and tissues comprising a normal and healthy body.
2. It aids in understanding the functions of various parts, their correlation and coordination, and their physical and functional relationship.
3. When normal shape, structure and function are known, a deviation from this normal can be recognized with great ease. Thus, it helps in the diagnosis and recognition of diseased state.
4. It provides knowledge, which helps in devising the ways and means for the collection of material required for a definite diagnosis.
5. It facilitates the development of more efficient means for the administration of drugs, not to talk of reducing the drug administration hazards.
6. A good grasp of anatomy gives much help and confidence to a surgeon.

DIVISIONS OF ANATOMY

GROSS ANATOMY

It is the study of structures that can be dissected and observed with the naked eye.

HISTOLOGY

It is the study of minute structures too small to be seen without a microscope.

CYTOLOGY

It is the study of minute structures in even greater detail, with the help of an electron microscope.

MORBID ANATOMY

It is the study of diseased structures of an organism.

APPLIED ANATOMY

It is the practical application of a normal structural study in relation to diagnosis and treatment of pathology or surgical condition.

TERATOLOGY

It is the study of abnormal development of an individual including their nature and causes of the problem.

DEVELOPMENTAL ANATOMY

It is the study of the development of an individual from the zygote to adult.

EMBRYOLOGY

It is the study of structure from fertilized egg to birth.

COMPARATIVE ANATOMY

It is the study of comparison of the structures of animals and it form the basis of their classification.

MORPHOLOGICAL OR PHILOSOPHICAL ANATOMY

It is the study of generalization made on outer form and inner structure and development of individuals belonging to different species.

PHYLOGENY

It is the study of evolutionary history of specie e.g. the study of changes occurred during process of evolution.

SPECIAL ANATOMY

It is the description of structure & form of a single type or specie e.g. hippotomy(anatomy of horse).

VETERINARY ANATOMY

It is the study of structure and form of domesticated animals e.g. horse, ox, dog, sheep, goat, and poultry birds.

METHODS OF STUDY OF ANATOMY

There are two chief methods of study which are usually employed.

1. Systemic Study
2. Topographic Study

1. SYSTEMIC STUDY

In this approach, the body is regarded as consisting of organs or apparatus which are similar in origin and structure and are associated in the performance of certain functions.

DIVISIONS OF SYSTEMIC ANATOMY

1. **OSTEOLOGY:**
The description of the skeleton.
2. **ARTHROLOGY**
The description of the Joints.
3. **MYOLOGY:**
The description of the muscles.
4. **SPLANCHNOLOGY:**
The description of the Viscera. This includes the following subdivisions of the soft organs of the body:-
 - i. Digestive System

- ii. Respiratory System
 - iii. Urinary System
 - iv. Genital System (Reproductive System)
5. **ANGIOLOGY:**
The description of the organs of circulation.
 6. **NEUROLOGY:**
The description of the nervous system
 7. **ESTHESIOLOGY:**
The description of the sense organs and common integument.

2. TOPOGRAPHIC STUDY

The term topographic anatomy designates the methods by which the relative positions of various parts of the body are accurately determined.

TOPOGRAPHIC TERMS

Following are some special terms which are usually employed in anatomical study. It is assumed that the animal is in a standing position.

..... (See Figure 1.1 and 1.2)

- Dorsal / Superior:** relatively nearer to the top of head, body, back of neck, trunk or tail.
- Ventral / Inferior:** towards or relatively nearer to the underside of the head or body.
- Medial:** toward or relatively nearer to the median plane.
- Lateral:** relatively away from the median plane.
- Cranial / Anterior:** toward or relatively nearer to the head.
- Caudal / Posterior:** toward or relatively nearer to the tail.
- Rostral:** relatively nearer to the nose; applies to the head only.
- Oral:** towards the oral cavity.
- Aboral:** away from the oral cavity.
- Internal / Inner:** close to, or in the direction of, the cavity of a hollow organ.
- External / Outer:** away from the center of a hollow organ.
- Superficial:** relatively nearer to the surface of a body, or a solid organ.
- Deep:** relatively nearer to the center of a body or solid organ.
- Proximal:** relatively nearer to the main mass of the body or trunk.
- Distal:** away from the main mass of the body or trunk.
- Radial and Tibial:** denote the medial sides of the forelimb and hind limb in which the radius and tibial are located respectively.
- Ulnar and Fibular:** denote the lateral sides of the forelimb and hind limb in which the ulna and fibula are located respectively.
- Volar and Palmer:** denote caudal aspect of the forepaw on which the pads are located.
- Planter:** denotes caudal aspect of the hindpaw on which the pads are located.
- Axis:** the central line of a body or any of its parts.
- Axial:** relatively nearer to the axis.
- Abaxial:** away from the axis of a body or part.

PLANES OF THE BODY

(See Figure 1-3)

Plane:
A surface (real or imaginary) along which any two points can be connected by a straight line.

Median:
It refers to the median plane, which divides the body, including the head and tail, into right and left, two symmetrical halves. The term has also been applied to a plane dividing a limb longitudinally into halves.

Sagittal:

A plane parallel to the median plane.

Transverse / Segmental:

It refers to a plane perpendicular to the long axis of the body or part.

Dorsal / Oblique / Frontal Plane:

It runs at right angle to the median and transverse planes and thus divides the body into dorsal and ventral portions.

RECUMBENCY POSITIONS

(See Figure 1-4)

- i) Dorsal Recumbency
- ii) Ventral Recumbency
- iii) Lateral Recumbency

MEDICAL TERMS FOR VARIOUS SPECIES

In veterinary medicine, there are many different species and many different terms used to describe animal anatomy and diseases.

Reviewing species-specific terms will allow you to communicate effectively with clients.

1. Common Anatomic Terms for Equine Species(See Figure 1-6)
2. Common Anatomic Terms for Cattle(See Figure 1-7)
3. Common Anatomic Terms for Goat(See Figure 1-8)
4. Common Anatomic Terms for Sheep (See Figure 1-9)
5. Common Anatomic Terms for Swine(See Figure 1-10)
6. Common Anatomic Terms for Cat(See Figure 1-11)
7. Common Anatomic Terms for Dog(See Figure 1-12)

COMMON ANIMAL TERMS

DOG

- Intact male dog
 - dog/stud
- Intact female dog
 - bitch
- Young dog
 - whelp or pup
- Giving birth
 - whelping
- Group of dogs
 - pack
- Multiple offspring born during the same litter
 - litter

CAT

- Intact male cat
 - tom
- Intact female cat
 - queen
- Young cat
 - kitten
- Giving birth
 - queening
- Multiple offspring born during the same litter
 - litter

SWINE

- Intact male pig

- boar
- Intact female pig
 - sow
- Male pig castrated when young
 - barrow
- Male pig castrated after maturity
 - stag
- Young female pig that has not given birth
 - gilt
- Young pig
 - pig or shoat
- Giving birth
 - farrowing
- Group of pigs
 - herd

HORSE

- Intact male horse more than four years old
 - stallion
- Intact male horse less than four years old
 - colt
- Intact female horse more than four years old
 - mare
- Intact female horse less than four years old
 - filly

- Castrated male horse
 - gelding
- Young horse
 - foal
- Giving birth
 - foaling

CATTLE

- Intact male bovine
 - bull
- Intact female bovine
 - cow
- Male bovine castrated when young
 - steer
- Young female bovine that has not given birth
 - heifer
- Young bovine
 - calf
- Group of cattle
 - herd
- Giving birth
 - freshening

SHEEP

- Intact male sheep
 - ram
- Intact female sheep
 - ewe
- Castrated male sheep
 - wether
- Young sheep
 - lamb
- Group of sheep
 - flock
- Giving birth

- freshening or lambing

GOAT

- Intact male goat
 - buck
- Intact female goat
 - doe
- Castrated male goat
 - wether
- Young goat
 - kid
- Group of goats
 - herd
- Giving birth
 - freshening or kidding

.....

Chapter 2

INTRODUCTION TO SKELETON

Outline

Introduction

Classification of Bones

Long bones

Short bones

Flat bones

Irregular bones

Sesamoid bones

Functions of a bone

Surface Contour of bone

Division of Skeleton

Movement terms

Bones of Axial Skeleton

Bones of Appendicular Skeleton

Skeleton is the framework of hard structures, which supports and protects the soft organs of the body. Skeleton of higher animals consists of mainly the bones, supplemented by cartilages in many places, and the binding tissue called the ligament. In the early embryonic development of an animal the skeleton consists largely of cartilages.

CLASSIFICATION OF BONES

The bones of the body are usually classified into five sub-classes.

1. LONG BONES

These are greater in one dimension than the other.

FUNCTION: long bones function chiefly as levers and aid in support, locomotion and prehension.

EXAMPLES: The bones of the limbs.

2. SHORT BONES

These are somewhat cuboidal or approximately equal in all dimensions.

FUNCTION: these function chiefly in absorbing concussion, and are found in complex joints such as knee or hock where a variety of movements as well as absorption of shock are required.

EXAMPLES: carpal and tarsal bones.

3. FLAT BONES

These are relatively thin, and expanded in two dimensions.

FUNCTION: these bones function chiefly for protection of vital organs e.g. brain, heart, lungs, pelvic viscera but also provide large surface for muscle attachment.

EXAMPLES: Scapula, frontal bone and ilium.

4. IRREGULAR BONES

These are unpaired bones located in the median plane of the body.

FUNCTION: these are important for protection, support and muscle attachment.

EXAMPLES: vertebrae and sternbrae.

5. SESAMOID BONES

These resemble a sesame seed and are developed along the course of tendons to reduce friction or change the course of tendons.

EXAMPLE: The patella (called knee cap) is the largest sesamoid bone in the body.

FUNCTIONS OF A BONE

1. It makes the foundation and a proper shape of the shape.
2. It supports and furnishes attachment to the soft organs of the body e.g. muscles and viscera etc.
3. It protects certain soft and delicate tissues of the body e.g. brain enclosed in the cranial cavity.
4. Bones act as levers in various articulations of the body and thus indirectly help in locomotion.
5. Bones of pneumatic type present in the fowl help in flying by reducing in flying by reducing weight of body.
6. It helps in erythropoiesis e.g. red and white blood cell formation.
7. It helps in hearing e.g. ossicles in ear.
8. It acts as storehouse of calcium and phosphorus.
9. They help in respiration e.g. ribs.
10. They help in deglutition e.g. hyoid apparatus.

SURFACE CONTOUR OF BONE

The surfaces of bones present a great variety of eminences, depressions and perforations which play a specific role in life.

There is a functional, embryological and pathological reason for the existence of every irregularity. The prominences and cavities may be articular or non-articular, serving for the attachment of muscles, fascia, ligaments, and tendons.

DESCRIPTIVE TERMS

A few of descriptive terms, which are frequently in use, are defined below:-

- Tuberosity (Tuber):** Is a large non-articular rounded projection.
- Tubercle:** Is a smaller tuberosity.
- Process:** Is a vague term generally applied to a projection.
- Trochanter:** Is a term specialized for a tuberosities on the femur.
- Spine:** Is an elongated thin pointed line.
- Crest:** Is a linear sharp ridge.
- Line:** Is a very faint ridge.
- Head:** Is a rounded, smooth, strongly convex articular projecting process, situated at the end of the long bones.
- Neck:** Is a constricted attachment between head and shaft of the bone.
- Condyle:** Is a smooth, convex, articular, large cylindrical, protruding mass situated at the end of the long bones.
- Epicondyle:** Is rough enlarged area, which lies proximal to the condyles.
- Facet:** Is a small articular surface, which may be flat, concave or convex.
- Glenoid Cavity (Cotyloid cavity):** Is a smooth and deep articular depression.
- Trochlea:** Is a large pulley-like articular mass.
- Cochlea:** Is an articular surface reciprocal to that of trochlea.
- Sinus:** Is an air cavity within a bone.
- Foramen:** Is a perforation in a bone.
- Canal:** Is a tunnel through one or more bones.
- Fossa:** Is a large non-articular depression.
- Fovea:** Is a small non-articular depression.

MOVEMENT TERMS

Where two or more bones unite with each other, a joint or articulation is formed.

The uniting medium may be fibrous tissue or cartilage. The various kinds of movements are as under:-

- Flexion:** When the angle between the uniting bones is reduced.
The muscles which are responsible for such movements are called flexors.
- Extension:** This is opposite to the flexion and it tends to bring the segments forming the joints in line with each other. The effecting muscles are called extensors.
- Adduction:** It is the movement of a limb towards the medial plane.
Effecting muscles are called adductors.
- Abduction:** It is the movement of a limb away from the medial plane.
Effecting muscles are called abductors.
- Rotation:** It is the rotation of one bone around the other longitudinal axis of the other segment forming the joint.
- Circumduction:** It refers to the movement in which distal end of limb describing a circular path whereas proximal end remains fixed. E.g. arm extended drawing a circle.
- Supination:** It is the lateral rotation of the appendages so that the palmar surface of the paw faces radially or dorsally.
- Pronation:** It is the medial rotation of the appendages from the spine position, so that palmar/plantar surface is facing ventrally.

DIVISION OF SKELETON

The skeleton may be divided primarily into following three subdivisions.

1. **Axial Skeleton:**
It comprises the vertebral column, ribs, sternum, and skull.
2. **Appendicular Skeleton:**
It includes the bones of the limbs.
3. **Splanchnic / Visceral / Heterotopic Skeleton:**
It consists of certain bones developed in the substance of some of the viscera or soft organs e.g. *os penis* of the dog and *os cordis* of the ox.

BONES OF AXIAL SKELETON

SKULL				
Cranial part	Facial part	Vertebrae	Ribs	Sternum
Ethmoid	Incisive	Cervical	True (joined to	Sternebrae
Frontal	Lacrimal	Thoracic	sternum by	Manubrium
Interparietal	Mandible	Lumbar	cartilages)	Xiphoid
			False (not directly	process
Occipital	Maxilla	Sacral	connected to	
Parietal	Palatine	Coccygeal	sternum)	
Pterygoid	Nasal		Floating (fixed only	
Sphenoid	Turbinates		at vertebrae, last 1	
	(conchae)		pair)	
Temporal	Zygomatic			
Vomer	Hyoid apparatus			

BONES OF APPENDICULAR SKELETON

THORACIC LIMB		PELVIC LIMB	
Part of Limb	Bones	Part of Limb	Bones
Thoracic (shoulder) girdle	Scapula, clavicle, coracoid	Pelvic girdle	Sacrum, os coxae, few coccygeal vertebrae
Brachium (arm)	Humerus	Thigh	Femur
Antebrachium (forearm)	Radius, ulna	Crus (true leg)	Tibia, fibula
Carpus (knee)	Carpal bones	Tarsus (hock)	Tarsal bones
Metacarpus (cannon and splint bones)	Metacarpal bones	Metacarpus (cannon and splint bones)	Metatarsal bones
Phalanges (digits)	Proximal, middle, and distal phalanges Proximal and distal sesamoid bones	Phalanges (digits)	Proximal, middle, and distal phalanges Proximal and distal sesamoid bones

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Chapter 3

AXIAL SKELETON

Outline

Vertebral Column

- Vertebral formula
- Characteristics of a vertebra

Vertebral Canal

Cervical Vertebrae

Thoracic Vertebrae

Lumbar Vertebrae

Sacrum

- Sacral Canal

Coccygeal Vertebrae

Ribs (Costae)

Costal Cartilages

Sternum

Thorax

Skull of the Goat

- Dorsal surface
- Lateral surface
- Ventral surface
- Occipital surface

Mandible of the Goat

Vomer and Hyoid Bone

Axial skeleton consists of the skull, vertebrae, ribs, and the sternum.

SKULL		Vertebrae	Ribs	Sternum
Cranial part	Facial part			
Ethmoid	Incisive	Cervical	True (joined to sternum by cartilages)	Sternebrae
Frontal	Lacrimial	Thoracic		Manubrium
Interparietal	Mandible	Lumbar	False (not directly connected to sternum)	Xiphoid process
Occipital	Maxilla	Sacral		
Parietal	Palatine	Coccygeal	Floating (fixed only at vertebrae, last 1 pair)	
Pterygoid	Nasal			
Sphenoid	Turbinates (conchae)			
Temporal	Zygomatic			

VERTEBRAL COLUMN

INTRODUCTION

The vertebral column is the fundamental part of the skeleton. It consists of a chain of median, unpaired, irregular bones which extends from the skull to the end of the tail.

The column is subdivided for description into five regions, following letters are typically used to designate the respective region:

C	Cervical vertebrae, neck region
T	Thoracic, chest
L	Lumber, loin
S	Sacral, fused vertebrae
Cy	Coccygeal (caudal), tail

VERTEBRAL FORMULA

A vertebral formula for a given species consists of the letter symbol for each region followed by the number of vertebrae in that region in the given species.

The vertebral formula (for goat) is **C₇ T₁₃ L₆₋₇ S₄ Cy₁₆₋₁₈**

CHARACTERS OF A VERTEBRA

All typical vertebrae have a common plan of structure, which must be understood. The parts of which a vertebrae consists are; (1) the body (2) the arch and (3) the processes (i) articular processes (ii) spinous processes (iii) transverse processes (iv) Mammillary processes (v) accessory processes

THE BODY

- It is more or less cylindrical mass on which the other parts are constructed.
- The anterior and posterior extremities of the body are attached to the adjacent vertebrae, and are usually convex and concave respectively.
- The dorsal surface is flattened and enters into the formation of the vertebral canal.

THE ARCH

- It is constructed on the dorsal aspect of the body. It consists originally of two lateral halves, each of which is considered to consist of a pedicle and a lamina.
- The **PEDICLE** forms the lateral part of the arch, and is cut into in front and behind by the vertebral notches.
- The **LAMINAE** are plates which complete the arch dorsally, uniting with each other medially at the root of the spinous process.

The body and the arch form a bony ring which encloses the **VERTEBRAL FORAMEN**; the series of vertebral rings which in turn enclose the **VERTEBRAL CANAL**, which contains the spinal cord and its covering and vessels.

THE PROCESSES

(i) ARTICULAR PROCESSES

The articular processes, two anterior and two posterior, project from the borders of the arch. They present articular surfaces adapted to those of adjacent vertebrae.

(ii) SPINOUS PROCESS

The spinous process or spine is single, and projects dorsally from the middle of the arch. It varies greatly in form, size and direction in different vertebrae.

(iii) TRANSVERSE PROCESSES

These are two in number and project laterally from the sides of the arch or from the junction of the arch & body.

(iv) MAMMILLARY PROCESSES

These are found on the last few thoracic vertebrae. They are present between the transverse and anterior articular processes or on the latter.

(v) ACCESSORY PROCESSES

These when present, are situated between the transverse and posterior articular processes.

VERTEBRAL CANAL

- The vertebral canal corresponds in its curvature to that of the bodies.
- Its caliber varies greatly at different points; the greatest diameter is in the atlas; where it contains the dens of the axis, in addition to the spinal cord. It is very smaller in the axis.
- It widens considerably at the junction of the cervical and thoracic regions than at any preceding point.
- Beyond the middle to the lumbar region it again enlarges considerably to contain the lumbar enlargement of the spinal cord.
- The caliber diminishes very rapidly from the second sacral segment caudally, and the canal ceases to be complete at the fourth coccygeal vertebrae.

CERVICAL VERTEBRAE

PECULIARITIES

- The cervical vertebrae are seven in number.
- The first (atlas) and second (axis) cervical vertebrae are highly modified in conformity with the special functions of support and movements of the head.
- The sixth and seventh present special characters, but do not differ greatly from the type.
- With the exception of the first, they are quadrangular, massive and longer than the vertebrae of other regions.

FIRST CERVICAL VERTEBRAE (ATLAS)

- This vertebra is decidedly atypical in form & structure.
- The body and spinous process are absent.
- The transverse processes are modified into curved plates, the *wings* which project laterally.
- Two foramina, alar (cranial one) and intervertebral, perforate each wing.
- The lateral masses present two deep and oval cranial articular cavities, which receive the occipital condyles but the caudal articular surfaces are somewhat saddle-shaped.
- The dorsal arch presents a median dorsal tubercle and is flat ventrally.
- The ventral arch is thick, narrow and more curved than the dorsal. The dorsal face, on the caudal end presents a transversally concave articular surface, the *fovia dentis* (where dens of axis rests)

SECOND CERVICAL VERTEBRA (AXIS)

- The second cervical vertebra is named as axis.
- The cranial extremity of body presents centrally the dens or odontoid process and the cranial articular processes present cranial articular surface.
- The caudal extremity has a usual cotyloid cavity & the caudal articular processes are typical.
- The arch presents a notch on each side of its cranial border (in young subject) which is converted into lateral vertebral foramen later by mean of a ligament.
- The transverse processes are small, single, and projects caudally.
- The spinous process projects a little cranially and increases in height and thickness caudally.

THIRD, FOURTH AND FIFTH CERVICAL VERTEBRAE

The three vertebrae, third, fourth and fifth are also called typical cervical vertebrae.

Distinct Characteristics

- The body is long as compared to those of other vertebrae.
- The ventral surface presents a prominent “median ventral crest”.
- The **CRANIAL EXTREMITY** or head has quadrangular convex articular surface, which faces cranially.
- The **CAUDAL EXTREMITY** is larger and has nearly circular cotyloid cavity.
- The **ARCH** is large and strong. It consists of two parts; (i) dorsal wall or roof is formed by the lamina and the (ii) lateral walls by the pedicles. It is perforated on either side by a foramen which communicates with the transverse foramen. The **VERTEBRAL NOTCHES** on the pedicles are large.
- The **ARTICULAR SURFACES** are flat and much extensive; (i) cranial ones are directed dorso-medially, and the (ii) caudal ones ventro-laterally.
- The **TRANSVERSE PROCESSES** are large and plate-like which arises from the body. Between these is a transverse foramen through which the vertebral vessels and nerve pass. The processes divide laterally into cranial and caudal branches for muscular attachment.
- The **SPINOUS PROCESS** is well-developed and increase in height cranio-caudally. They are directed dorsally and cranially with the exception of the last, which is nearly vertical.

SIXTH CERVICAL VERTEBRA

- It is shorter and wider than the fifth.
- The arch is large, especially caudally.
- The cranial articular processes are further apart.
- The spinous process is less rudimentary; its summit is flattened from before backward.
- The transverse processes have two braches; the dorsal branch projects laterally and is short and stout, the ventral one is a thick and sagittal plate, which forms with its fellow of the opposite side.

SEVENTH CERVICAL VERTEBRA

- It is shorter and wider than the others.
- The body is flattened dorso-ventrally and wide caudally.
- The cranial articular processes are wider and longer than the caudal pair.
- The spinous process is about 3cm in height.
- The transverse process is undivided and usually has no transverse foramen.
- The ventral crest is absent.

THORACIC VERTEBRAE

Peculiarities

- The thoracic vertebrae are about 13 in number.
- The bodies are short but their ends are expanded have articular surfaces.
- The arches are small and their caudal notches are relatively notches.
- The articular processes are small; the cranial processes are represented by two oval facets on the cranial part of the arch, the caudal ones spring from the base of the spinous process.
- The transverse processes are short, thick, and tuberos at the free end. Each has a facet for articulation with the tubercle of the corresponding rib.
- The spinous process is large and narrow. It is directed dorso-caudally. The cranial border is thin, the caudal one is wider and grooved.

FIRST THORACIC VERTEBRA

- **The** body is wide and flattened dorso-ventrally.
- The cranial extremity presents a head which resemble to that of the cervical vertebrae.
- The caudal extremity presents a cavity somewhat deeper than any other thoracic vertebrae and two large costal facets are found on either side.
- The articular processes are much larger than those of other thoracic vertebrae and resemble a good deal those of the seventh cervical.

- The transverse processes are short and each has on its ventral aspect, a large concave facet for articulation with the tubercle of the first rib.
- The spinous process is inclined caudally.

LAST THORACIC VERTEBRA

- Absence of the caudal pair of costal facets and the confluence of the cranial pair with those on the transverse processes.

SERIAL POSITION

- ❖ The bodies gradually diminish in length and width to the middle of the region and then increase slightly.
 - The costal facets become smaller and less concave from first to the last.
 - The ventral crest is distinct on last three or four vertebrae of this region.
- ❖ The transverse processes diminish in size and are placed more ventrally as they are traced caudally.
 - The costal facets become smaller and lower in position; on the last it fuses with the costal facet of the body.

LUMBER VERTEBRAE

Peculiarities

- The lumbar vertebrae are usually six in number; five lumbar vertebrae have also been reported in the domestic goat.
- They are characterized by the size and form of their transverse processes.
- The **ARCHES** of the first three are semi-elliptical on cross section and present a distinct ventral crest. These (arches) are about equal in size and similar to that of the last thoracic.
- The **ARCHES** of last three increase in breadth and height.
- The **CAUDAL NOTCHES** on the pedicles are much deeper than the cranial ones.
- The **CRANIAL ARTICULAR PROCESSES** are fused with the mammillary processes and present medially a large concave and more strongly curved surfaces for articulation with the caudal pair of preceding vertebra.
- The **CAUDAL ARTICULAR PROCESSES** project distinctly from arch at the base of the spinous process.
- The **TRANSVERSE PROCESSES** are elongated plates, flattened dorso-ventrally which project laterally and all inclines cranial and ventral. Their length increases to the fifth, and then diminishes to the last.
- The **SPINOUS PROCESSES** are relatively low and wide, the last being the smallest. Their summits are moderate thickened.

SACRUM

Peculiarities

The sacrum is usually formed by the fusion of four vertebrae and conveniently described as a single bone.

The sacrum is triangular in form and is wedged in between the ilia, with it articulates very firmly on each side.

Its long axis is gently curved and slightly oblique, so that the casual end is a little higher than the cranial.

DESCRIPTION

The sacrum presents:

Two surfaces, Two borders, a base and an Apex

THE SURFACES

DORSAL SURFACE: presents centrally four sacral spines, which are directed dorsal and caudal and have thick summits. On either wide of the spines there is a groove in which are the three

dorsal sacral foramina; the dorsal branches of the sacral spines, nerves emerge through them.

On the lateral side of the dorsal sacral foramina are a series of tubercles representing the fused transverse processes of the sacral vertebrae, which form the lateral sacral crest. In older goats the dorsal spines may fuse to form the median sacral crest.

PELVIC SURFACE: is concave in its length, and is wide cranially, and narrow caudally. It is marked by three more or less distinct transverse lines, which indicate the demarcation of the bodies of the vertebrae. At the ends of these lines are the pelvic sacral foramina, which are larger than the dorsal series and diminish in size from first to last; they transmit the ventral branches of the sacral spinal nerves. The dorsal and pelvic sacral foramina communicate with the sacral canal and are together equivalent to the usual inter-vertebral foramina.

THE BORDERS

LATERAL BORDERS: are rough, and thin, the base is directed cranial and is relatively very wide. It presents centrally the body of the first sacral segment which is wide transversally, flattened dorso-ventrally, and has a rounded surface, which articulates with the last lumbar vertebrae by means of an inter-vertebral disc.

The ventral margin projects slightly, forming the promontory.

Dorsal to the body is the entrance to the sacral canal, flanked by a pair of cranial articular processes, which project dorsal and cranial from the arch and have concave surfaces medially for articulation with those of the last lumbar vertebrae.

THE BASE

The lateral parts of the base, the alae or wings, are compressed and strongly curved masses. Caudally there is an elongated oval area, which faces dorso- laterally; this is the auricular surface, which articulates with the ilium; it is slightly concave in its length and somewhat rough and irregular. The rest of the ventral surface of the wing is roughened for ligamentous attachment.

THE APEX

It is the caudal aspect of the last sacral vertebrae and is quite small. It presents flattened caudal surface of the body, dorsal to which is the triangular caudal opening of the sacral canal, surrounded by the last sacral spine.

There is a pair of narrow notches between the arch and the body, dorsal to which rudiments of caudal articular process may occur.

SACRAL CANAL

The name applies to that part of the vertebral canal, which traverses the sacrum.

Its **CRANIAL PART** is large and has the form of a triangle with angles rounded off; its width is nearly twice its height.

Traced **CAUDALLY** it is seen to diminish in size rapidly, and the caudal opening is small and also triangle.

COCCYGEAL VERTEBRAE

Peculiarities

- The coccygeal (=caudal) vertebrae vary considerably in number, but 18 may be taken as an average.
- From first to last gradually become reduced in size and, with the exception of a few at the beginning of the series, consist of bodies only.
- The **FIRST THREE** have bodies, which are somewhat flattened dorso-ventrally, constricted in the middle and have at both ends convex, elliptical articular surfaces.

CHARACTERISTICS

- The **VENTRAL SURFACE** has a median groove for the median coccygeal artery.
- The **ARCH** is small and triangular; it is formed of two flat plates, which are prolonged to form a short spinous process with a thickened and often double summit.
- The **CRANIAL NOTCHES** are absent.
- Functional **ARTICULAR PROCESSES** are not present but small processes are relatively large plates, which project horizontally laterad. Further caudal the arch becomes incomplete

dorsally and soon disappears; the transverse processes gradually fade out and the vertebrae are reduced to cylindrical rods of diminishing size.

- The **LAST ONE** has a pointed end.

RIBS (COSTAE)

CLASSIFICATION: Modified long bones

LOCATION: between the thoracic vertebrae and the sternum.

DESCRIPTION

- The ribs are elongated curved bones, which form the skeleton of the lateral thoracic wall.
- They are arranged serially in pairs, which correspond in number to the thoracic vertebrae.
- They are usually 13 pairs of ribs, but a 14th rib on one side or both is not uncommon.
- Each rib articulates dorsally with two contiguous vertebrae and is continued ventrally by a costal cartilage.

TRUE OR STERNAL RIBS are those, which articulate with the sternum by means of their cartilages, are termed as true or sternal ribs. The remainder is **FALSE OR ASTERNAL RIBS**.

At the end of the series, which have their ventral ends free and not attached to an adjacent cartilage are named as **FLOATING RIBS**.

Total Pair of Ribs	Sternal	Asternal	Sternebrae
13	8	5	7

- The intervals between the ribs are termed “Intercostal spaces”.
- Ribs from different parts of the series vary greatly in length, curvature and other characteristics.

CHARACTERISTICS OF A TYPICAL RIB

The rib consists of a body and two extremities;

THE BODY

The body or shaft is band like and varies in length, breadth and curvature in different ribs. The *curvature* is not uniform but is accentuated at a certain point, termed the *angle of the rib*, which is most pronounced in the dorsal third and marked by a rough ridge.

THE SURFACES

The **Lateral surface** is convex in its length and also transversely; its cranial part is, however, grooved longitudinally.

The **Medial surface** is smooth, concave in its length, and rounded from side to side. The costal groove; situated caudally, is very distinct dorsally and fades out about the middle; it contains the dorsal intercostal vessels and intercostal nerve.

THE BORDERS

The **cranial** and **caudal** borders are thin and sharp on some ribs, rounded on other.

THE EXTREMITIES

The **vertebral extremity** consists of the head, neck and tubercle.

The **HEAD** is actual end of the rib and is rounded and somewhat enlarged. It presents two convex facets, cranial and caudal, for articulation with the bodies of two adjacent thoracic vertebrae, except the first, which articulates with the seventh cervical and first thoracic.

The **NECK** joins the head to the body and is roughened dorsally and cranially and varies in length and diameter. Its lateral surface is rough and medial is smooth.

The **TUBERCLE** projects caudally at the junction of the neck and body. It has a facet for articulation with the transverse process. The tubercle gradually approaches the head in the caudal ribs and eventually fuses with it.

The **ventral extremity** is commonly slightly enlarged and is roughened at the junction with the costal cartilage (costo-chondral junction).

FIRST RIB

- It is easily distinguished.
- It is the shortest and the shaft widens greatly toward the ventral end.
- The costal groove is absent.
- The head is large and has two facets of unequal extent, which meet at an acute angle cranially; the smaller one faces cranial and articulates with the last cervical vertebra; the large one is directed medially and articulates with the first thoracic vertebra.
- The neck is thick and very short.
- The tubercle is larger than that of any other rib and has an extensive articular surface, which is convex in its length.
- The ventral end is larger than that of any other rib; it is thick and very wide and is turned a little cranial.

LAST RIB

- It is the most slender and regularly curved.
- It is usually equal but little longer than the second.
- The facet on the tubercle is confluent with that of the head.

SERIAL POSITION OF THE RIBS

The serial position of the ribs may be determined approximately by the following consideration:

- ▶ The length increases from the first to the fifth and eighth and then diminishes.
- ▶ The width increases somewhat to the seventh and then diminishes.
- ▶ The groove of the lateral surface is distinct on the fourth to the tenth inclusive.
- ▶ The curvature increases in degree rapidly from the second to the eighth and then decreases very noticeably.
- ▶ In regard to dorso-ventral direction, the first rib inclines a little cranial and the second is about vertical; caudal to this they slope caudal in increasing degree so that a transverse plane tangent to the ventral ends of the last pair cuts the third lumbar vertebrae.
- ▶ The head and tubercle diminish in size from first to last. The relative positions change, in that the tubercle of the first rib is almost directly lateral to the head, further caudal it gradually comes to lie caudal to it.
- ▶ The neck is longest on the longest rib and is absent on the last two or three.

COSTAL CARTILAGES

The costal cartilages are bars of hyaline cartilage, which continue the ribs.

Those of **TRUE RIBS** articulate with the sternum and those of **FALSE RIBS** overlap and are attached to each other by elastic tissue to form the costal arch.

COSTAL CARTILAGES OF STERNAL RIBS

The first costal cartilage is 2.5 to 3cm in length. The **DORSAL END** is very wide and thick. The sternal end is small. The two articulate with each other as well as with the sternum.

The cartilages of the other sternal ribs are more rounded. The **STERNAL END** is enlarged and has an elliptical convex facet for articulation with sternum.

COSTAL CARTILAGES OF ASTERNAL RIBS

The costal cartilages of asternal ribs are long, slender and pointed. They overlap and are attached to each other by elastic tissue, forming the costal arch, as indicated above.

The seventh is very firmly attached to the eighth; it and the next two are the longest. Caudal to this they diminish progressively in size.

- ▶ Except in case of the first, the cartilage does not continue the direction of the rib but form with the latter an angle, which is open cranially and increases in size from second to last.

STERNUM

The sternum is composed of six unpaired segments; the *sternebrae*.

Consecutive sternbrae are joined by the inter-sternbral cartilage.

FIRST STERNEBRA

It is also known as *manubrium*, ends cranially in a club-like enlargement.

LAST STERNEBRA

It is flattened dorso-ventrally and is called the *xiphoid process*. The caudal end of this process is continued by a thin plate of the cartilage.

COSTAL NOTCHES

There are six to seven costal notches, with which the sternal ends of the second to the seventh costal cartilages, inclusive articulate. These notches are situated in series at the inter-sternbral junctions. They are separated by considerable regular intervals. The area ventral to these notches gives attachment to the pectoral muscles.

THORAX

The bony thorax is remarkably compressed laterally in its cranial part but widens greatly caudally.

CRANIAL/THORACIC APERTURE OR THORACIC INLET

It is oval and very narrow. In a goat of medium size; its greatest width is 10cm and its height is 18cm to 20cm.

The **VENTRAL WALL** or **ROOF** is about 40cm long and the **DORSAL WALL** or **ROOF** about 95 to 100cm long.

The height of the last segment of sternum is about 45cm more than twice that of the cranial aperture; this is due to obliquely and divergence of roof and floor.

- The greatest width of the caudal aperture is about 50 to 60cm.
- The intercostal spaces (measured in their middle) averages about 30cm in width. The first is narrow and they widens to the fourth of fifth. Further caudal they gradually diminish to the last two or three, where they again increase.

THE SKULL OF GOAT

CLASSIFICATION: A group of flat and irregular bones.

LOCATION: At the cranial extremity of the vertebral column.

DESCRIPTION

The skull is divided into two parts, viz. the cranium and the face.

CRANIUM

The cranium is composed of the bones of the skull which immediately surround the brain and which are incorporated into the floor and vault of the brain cavity.

FACE

The face consists of the bones of the skull which are not the part of the cranium.

BONES OF THE CRANIUM

BONES OF THE FACE

BONES OF THE CRANIUM		BONES OF THE FACE	
<i>Single Bones</i>	<i>Paired Bones</i>	<i>Single Bones</i>	<i>Paired Bones</i>
Occipital	Frontal	Vomer	Maxilla
Sphenoid	Temporal	Hyoid	Premaxilla (incisive)
Ethmoid	Parietal		Palatine
	Interparietal		Pterygoid
			Nasal
			Lacrimal
			Malar (zygomatic)
			Turbinates (conchae)
			Mandible

GENERAL SHAPE AND FORM

The skull of the goat, as a whole, is in the form of a long, four sided pyramid, the base of which is caudal. It is convenient to exclude the mandible and hyoid from present consideration.

DORSAL (FRONTAL) SURFACE

It is formed by the Interparietal, parietal, frontal, nasal and incisive bones. It may be divided into parietal, frontal, nasal, and incisive regions.

Parietal region

It extends from the nuchal crest to the parieto-frontal suture. In most breeds, the sagittal crest is replaced by a pair of paramedian curved temporal lines

Frontal region

It is smooth and widest part of the surface. This surface is divided by a "V" shaped frontal ridge into two areas. At the caudal end of these ridges are the *cornual processes* for support of the horn. In the polled breeds, these processes are absent. The frontal region is bounded rostrally by the fronto-nasal suture.

Nasal region

It is convex from side to side, wide posteriorly and narrow rostrally. Thus, its profile is convex. The rostral end is divided by a deep notch.

Incisive region

It presents the osseous nasal aperture and the inter-incisive fissure.

LATERAL SURFACE

It may be divided into cranial, orbital and maxillary regions.

Cranial region:

It presents the temporal fossa, zygomatic arch and the outer part of the petrous part of the temporal bone.

Temporal fossa:

It is bounded medially by the temporal lines, laterally by the temporal crest and the zygomatic arch, and caudally by the nuchal crest. The fossa is continuous rostrally with the orbital cavity.

Zygomatic arch:

The zygomatic arch is formed by the zygomatic processes of the temporal and zygomatic bone. Its ventral face presents the articular tubercle and mandibular fossa for articulation with the lower jaw.

External acoustic meatus:

It projects outward through a deep notch in the ventral margin of the squamous part of the temporal bone ventral to the temporal crest.

Mastoid process

They are located a little caudal to the external acoustic meatus.

Orbital region:

It comprises the orbit and the pterygopalatine fossa.

Orbit:

The orbit is a cavity which encloses the eyeball(globe), with the muscles, vessels, and nerves associated with it. It is directly continuous caudally with the temporal fossa.

The **medial wall** is complete and extensive. It is concave and smooth, and is formed by the frontal, lacrimal and the wing of the presphenoid.

The **dorsal wall** is formed by the frontal and to a small extent, by a small part of lacrimal bone.

The **ventral wall** is very incomplete, and is formed by the zygomatic bone and the zygomatic process of the temporal.

The **lateral wall** is the zygomatic process.

Orbital group of foramina:

The orbital group of foramina is located at the extreme caudal part of this region.

Four are situated rostral to the pterygoid crest.

- (i) **Ethmoid foramen:** is the most dorsal one which transmits the ethmoid vessels and nerves.
- (ii) **Optic foramen:** is situated a little more ventrad and further caudad. It transmits the optic nerve.
- (iii) **Foramen orbitotendinum:** is located just ventral to the optic.
- (iv) **Foramen oval:** is situated caudal and ventral to the preceding one. It opens into the cranial cavity.

Pterygopalatine fossa:

Ventral to the orbital cavity is the pterygopalatine fossa. Its wall is formed by the pterygoid process, the perpendicular part of the palatine bone and the maxillary tuber. Its deep rostral recess contains three foramina;

- (i) The dorsal one **Maxillary foramen** is the entrance of the infra-orbital canal: which transmits the infra-orbital nerve and vessels.
- (ii) The **spheno-palatine foramen** perforates the medial wall of the recess and transmits vessels and nerves of like name to the nasal cavity.
- (iii) The ventral foramen **Major palatine**, transmits the major palatine artery and nerve. The dorsal part of the fossa is smooth, the ventral part is chiefly roughened for the attachment of the pterygoideus lateralis.

Maxillary region:

The maxillary region is chiefly formed by the maxilla, but also by the incisive (premaxilla) and the facial parts of the lacrimal and zygomatic bones.

Its contour is approximately triangular, the base being caudal. It offers two principal features:

- (i) **Facial crest:** extends rostrad from the middle of the rostral margin of the orbit, and ends abruptly at a point about 3 to 3.5 cm dorsal to the 3rd or 4th cheek tooth; its ventral aspect is rough for the attachment of the masseter muscle.
- (ii) **Facial tubercle:** is present about 1 cm above the 3rd and 4th cheek tooth.

Infra-orbital foramen:

It is situated about 2 to 3 cm rostral to the end of the facial tubercle. The foramen opens rostrad, and via it, the infra-orbital artery and nerve emerge.

VENTRAL (BASAL) SURFACE

The ventral or basal surface, exclusive of the mandible consists of cranial, choanal, and palatine regions.

Cranial region:

It extends rostrally to the vomer and pterygoid processes.

Foramen magnum and Condylloid fossa:

At its caudal end is the foramen magnum, flanked by the occipital condyles. Lateral to these is the condylloid fossa, in which the hypoglossal canal, which transmits the hypoglossal nerve and condylloid vein. Further laterad are the jugular processes of the occipital bone. Extending rostrad centrally is a plate, formed by the basilar part of the occipital and the body of the basi-sphenoid bone; at the junction of these parts are tubercles for the attachment of the rectus capitis ventralis and logus capitis muscles.

Laterally the basilar part of the occipital bone is bounded by the petroccipital fissure and the foramen lacerum rostrally. Rostral to these, the region becomes very wide in account of the lateral extension of the zygomatic processes, which present ventrally the articular tubercle and mandibular fossa for articulation with the mandible. Beyond this, the process turns rostrad and joins the temporal process of the zygomatic bone, completing the zygomatic arch and the surface for the attachment of masseter muscle.

On either side of the body of the basi-sphenoid is the **infratemporal fossa**, formed by the wing and the root of the pterygoid process of the basi-sphenoid bone. It is bounded

rostrally by the *pterygoid crest*, which separates it from the orbit and *pterygopalatine fossa*. Just ventral is the entrance to the *pterygoid canal*.

Choanal region:

The choanal region presents the pharyngeal orifice of the nasal cavity. This region is divided in its depth (i) **medially** by the vomer into two narrow choanae. It is bounded (ii) rostrally and (iii) laterally by the palatine and pterygid bones, (iv) caudally by the vomer. It is flanked by the *hamulus process* of the pterygoid bone. The plane of the opening is nearly horizontal, and the length is about twice the width.

Palatine region

It comprises a little less than half of the entire length of the base of the skull. The hard palate is concave from side to side, and in its length also in the rostral part. It is formed by the palatine processes of the incisive and maxillae, and the horizontal plates of the palatine bones.

It is circumscribed rostrally and laterally by the alveolar parts of the maxillae and incisive.

Inter-alveolar space: is that part of the arch in which alveoli are not present. Caudal to the last alveolus is a tuberosity. On the midline is the *median palatine suture*. The palatine fissure is the narrow interval along the lateral margin of the palatine process of the incisive; it is closed in the fresh state by the vomeronasal cartilage.

The transverse palatine suture is about 1.5 cm from the caudal border. The latter is opposite to the fourth or fifth cheek tooth in the adult.

OCCIPITAL (NUCHAL) SURFACE

The occipital or nuchal surface is formed by the occipital bone. It is pentagonal in outline, wider dorsally and convex transversally. It is separated from the dorsal surface by the nuchal crest. Ventral to the crest are two rough areas for the attachment of the semispinalis capitis. A little more ventral is a central eminence, the external occipital protuberance. On which the nuchal ligament is attached. At the most ventral part centrally is the foramen magnum. This is bounded laterally by the occipital condyles, lateral to which is the *jugular process*.

- The apex of the skull is formed by the bodies of the incisive and mandible.

MANDIBLE OF GOAT

The mandible is the largest bone of the face and forms the lower jaw.

FORMATION

It is composed of two halves which fuse cranially at the symphysis mandibulae and is considered as a single bone. It contains the lower teeth and articulates with the squamous temporal at the condyloid fossa.

DESCRIPTION

The mandible consists of a body and two rami (singular: ramus) and possesses two pair of major foramina, the mental and the mandibular.

THE FORAMINA

The mental foramina are located laterally on the body midway between the first premolars and the canine teeth.

The mandibular foramina are located medially about halfway of the rami. These foramina are the caudal opening of the mandibular canal.

MANDIBULAR CANAL

The mandibular canal is located in the ramus and body of the mandible. It transmits the mandibular artery and veins and the mandibular alveolar nerve. The mandibular foramen is the caudal opening of the mandibular canal whereas it opens rostral at the mental foramen.

VOMER & HYOID BONE

VOMER BONE

The vomer is the medial bone which enters into the formation of the ventral part of the septum nasi. It is grooved to receive the perpendicular plate of the ethmoid bone and the septal cartilage. The cranial extremity lies above the palatine process of the premaxilla (incisive).

HYOID BONE

LOCATION

The hyoid bone lies mainly between the rami of the mandible.

ATTACHMENTS

Caudally it is attached by cartilaginous rods, the tympanohyoids, to the styloid process of the petrous part of the temporal bones. Rostrally it is associated with the tongue, pharynx and larynx.

DESCRIPTION

The hyoid bone is composed of number of parts; some single and other are paired.

- 1) The **basihyoid** is short and flattened and lies in a transverse plane.
- 2) A short **lingual process** is situated centrally on the rostral.
- 3) The paired **thyrohyoid** is not firmly attached to the basihyoid. They are long (2.5 to 3 cm) and narrow and articulate caudally with the rostral cornua of the thyroid cartilage of the larynx.
- 4) The **ceratohyoid** and 5) **epihyoid** are small rounded bones situated on each side between the basihyoid and the stylohyoid.
- 6) The **stylohyoid** articulates rostrally with the epihyoid and caudally with the styloid process of the temporal bone. The bone is elongated, flattened and about 6cm long and 5mm wide. The rostral end is slightly expanded, while the caudal end bifurcates.
- 7) The dorsal part of the caudal end articulates with the styloid process of the temporal bone by the **tempanohyoid**, 8) and the ventral part is the **muscular process**.

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Chapter 4

APPENDICULAR SKELETON

Outline

Overview of Appendicular Skeleton

Introduction to the Thoracic Limb

Bones of the Thoracic Limb

- Scapula
- Humerus
- Radius
- Ulna
- Carpals bones
- Metacarpal bones
 - o Large metacarpal
 - o Small metacarpal
- Digits

Introduction to the Pelvic Limb

Bones of the Pelvic Limb

- Os coxae
 - o Ilium
 - o Ischium
 - o Pubis
- Femur
- Tibia
- Fibula
- Patella
- Tarsal bones
- Metatarsal bones
 - o Large metatarsal
 - o Small metatarsal
- Digits

OVERVIEW OF APPENDICULAR SKELETON

THORACIC LIMB		PELVIC LIMB	
Part of Limb	Bones	Part of Limb	Bones
Thoracic (shoulder) girdle	Scapula, clavicle, coracoid	Pelvic girdle	Sacrum, os coxae, few coccygeal vertebrae
Brachium (arm)	Humerus	Thigh	Femur
Antebrachium (forearm)	Radius, ulna	Crus (true leg)	Tibia, fibula

Carpus (knee)	Carpal bones	Tarsus (hock)	Tarsal bones
Metacarpus (cannon and splint bones)	Metacarpal bones	Metacarpus (cannon and splint bones)	Metatarsal bones
Phalanges (digits)	Proximal, middle, and distal phalanges	Phalanges (digits)	Proximal, middle, and distal phalanges
	Proximal and distal sesamoid bones		Proximal and distal sesamoid bones

INTRODUCTION TO THE THORACIC LIMB

The thoracic limb consists of four chief segments, viz., the shoulder girdle, the arm, the forearm, and the manus.

1. SHOULDER GIRDLE

The shoulder girdle, when fully developed, consists of three bones__ i) **Scapula** (or shoulder-blade) ii) **Coracoid** iii) **Clavicle**.

In the domesticated mammals only the scapula, a large flat bone, is well developed, and the small coracoid element has fused with it, while the clavicle is either absent or is a small rudiment embedded in the brachiocephalic muscle. Therefore, there is no articulation of the shoulder with the axial skeleton.

2. ARM

The arm contains a single large bone, the **humerus** (or arm bone).

3. FOREARM

In the forearm are two bones, the **radius** and **ulna**. These vary in relative size and mobility.

4. MENUS

The manus, the homologue of the hand in man, consists of three subdivisions;

a) CARPUS

It is popularly termed the “knee” in animals. It contains a group of short bones, the ossa *carpi*. These are typically seven in number and are arranged in two transverse rows __ a proximal and a distal row.

b) METACARPUS

It contains typically three metacarpal bones; of which third and fourth metacarpals are fused to form a large bone and the fifth one is a separate small bone (splint bone).

c) DIGITS

In goat, four digits are present. Out of these four, only two; **THIRD (III)** and **FOURTH (IV)** are fully developed and has three *phalanges* and three *sesamoids* each.

BONES OF THE THORACIC LIMB

Scapula

CLASSIFICATION: Flat bone

LOCATION: The scapula covers the cranial part of the lateral thoracic wall.

DESCRIPTION

Scapula is roughly triangular in outline. It is wider at dorsal end and narrow at ventral end. It has two surfaces, three borders, and three angles.

THE SURFACES

The **LATERAL SURFACE** has a spine of scapula and two fossae. The *spine* increases gradually in height dorso-ventrally and inclines cranially. Its free edge is rough and is in the greater part subcutaneous. Spine divides the lateral surface into two unequal fossae i.e. supraspinous and infraspinous. The *supraspinous fossa* is located cranially and is narrower. The *infraspinous fossa* is situated caudally and is wider. The *acromion process* is short and blunt and is opposite to the neck of scapula.

The **COSTAL OR MEDIAL SURFACE** is hollowed in its length by the *subscapular fossa*, which is deep and has a rough area. The rough triangular area dorsal to it is, the *facies serrata*, which are not distinct. However it larger and quadrilateral cranially, narrow and marginal caudally.

THE BORDERS

The **CRANIAL (ANTERIOR) BORDER** is thin and sharp. It is convex dorsally and concave distally.

The **CAUDAL (POSTERIOR) BORDER** is straight and thick proximally while the slight concave distally. The *nutrient foramen* is usually in the ventral third of the caudal border.

The **DORSAL BORDER** is rough, thick, straight, and porous and bears a band of scapular cartilage.

THE ANGLES

The **CRANIAL ANGLE** lies at the junction of the cranial and dorsal border and is opposite to the first thoracic spine.

The **CAUDAL ANGLE** is formed by the junction of the caudal and dorsal border. It lies dorsal to the vertebral end of the fourth rib.

The **GLENOID ANGLE** is long and thick. It lies at a point just cranial to the sternal end of the first rib in the ordinary standing position. The *neck* is well-defined and narrow. The *glenoid cavity* is continued cranially upon the ventral surface of the *supra-glenoid tubercle*. It is bent & bears a small *coracoid process* projecting from its medial surface.

MUSCLE ATTACHMENT

Bony Feature	Muscles originated	Muscles inserted
Tuber spinae	----	Trapezius Omo-transversarius
Serrated facies	----	Serratus ventralis
Scapular cartilage	----	Rhomboideus
Subscapular fossa	Subscapularis	----
Acromion process	Deltoideus	----
Coracoid process	Coracobrachialis	----
Supraspinous fossa	Supraspinatus	----
Infraspinous fossa	Infraspinatus	----
Caudal border	Teres major Teres minor Tensor fascia antibrachii Triceps brachii (long head)	----
Supraglenoid tubercle	Biceps brachii	----

Humerus

CLASSIFICATION: Long bone

LOCATION: It lies between the scapula and the radius, ulna.

DESCRIPTION

Humerus is a long and slender bone which extends from the shoulder proximally where it articulates with the scapula to the elbow distally, where it articulates with the radius and ulna.

It is directed obliquely, distally and caudally. It consists of a shaft (body) and two extremities.

THE SHAFT

It is irregularly cylindrical and has a twisted appearance. It may describe as having four surfaces.

The **LATERAL SURFACE** is smooth and spirally curved forming the *musculo-spiral (brachialis) groove*, which contains the brachialis muscle. The groove is continuous with the caudal surface proximally and distally where it winds around cranially.

The **MEDIAL SURFACE** is nearly straight in its length, rounded from side to side and blends with the cranial and caudal surfaces. Just proximal to its middle is the *teres major tuberosity*.

The **CRANIAL SURFACE** is triangular wide and smooth proximally, narrow and smooth distally. It is separated from the lateral surface by a distinct border, the *crest of the humerus*, which bears proximal to its middle, the *deltoid tuberosity*.

The **CAUDAL SURFACE** is rounded from side to side and smooth in its length. It is concave in proximal half and convex in distal half along its long axis.

THE PROXIMAL EXTREMITY

It consists of the head, neck, two tuberosities and inter-tuberal groove.

The **HEAD** presents an almost circular convex articular surface, which is twice as extensive as the glenoid cavity of the scapula, with which it articulates.

The **NECK** is well-defined caudally but is practically absent elsewhere.

The **GREATER TUBERCLE** (lateral tuberosity) is placed cranio-laterally and consists of two parts; the cranial part forms the lateral boundary of the inter-tuberal groove, which curves medially over the inter-tuberal groove. The caudal part gives attachment to the short insertion of infraspinatus.

The **LESSER TUBERCLE** (medial tuberosity) is less salient and consists of cranial and caudal parts. The cranial part forms the medial boundary of the inter-tuberal groove. The caudal part gives attach-ment to the subscapularis M.

The **INTER-TUBERAL OR BICIPITAL GROOVE** is deflected cranio-medially; it is bounded by the cranial parts of the tubercles. The groove is covered in the fresh state by cartilage and lodges the tendon of origin of the biceps brachii muscle.

THE DISTAL EXTREMITY

The **DISTAL EXTREMITY** or **HUMERAL CONDYLE** in conformity is decidedly oblique; it consists of the lateral and medial epicondyles, the olecranon and radial fossae. It has sagittal surface for articulation with the radius and ulna, which consists of the trochlea medially and the capitulum laterally.

The **DISTAL GROOVES** and **RIDGES** are very well marked.

The **TROCHLEA** is much the larger, on the cranial part of which there is usually a synovial fossa. Caudally the groove extends proximally, considerably proximal to the rest of the articular surface and reaches the olecranon fossa. This part articulates with the trochlear notch of the ulna.

The lateral portion of the **CAPITULUM** is larger and is placed somewhat more proximal and further caudally.

The **RADIAL FOSSA** is situated cranially, proximal to the groove on the trochlea.

The **OLECRANON FOSSA** is quite deep and situated caudally between the epicondyles; in to which the anconeal process of the ulna projects. Both the fossae (radial and olecranon) are deep and wide.

The **LATERAL** and **MEDIAL EPICONDYLES** are two thick ridges present caudally proximal to the trochlea. The medial epicondyle is more salient. The lateral epicondyle bears laterally, the epicondyloid crest, which forms the lateral boundary of the musculo-spiral groove. The nutrient foramen is usually present on the said crest, at the junction of the middle and distal third of the shaft.

MUSCLE ATTACHMENT

Bony Feature	Muscles Originated	Muscles Inserted
Greater tubercle	---	Infraspinatus
Lesser tubercle	---	Subscapularis
		Superficial pectoral

Ant. part of proximal tuberosities.	---	Supraspinatus
Deltoid tuberosity	Triceps brachii (lateral head)	Deltoideus Teres major
Teres major tuberosity	---	Teres major Latissimus dorsi Coraco-brachialis
Crest of humerus	---	Deep pectoral Brachiocephalicus
Medial surface of shaft	Triceps brachii (medial head)	
Caudal surface of shaft	Brachialis	---
Lateral condyloid crest	Extensor carpi radialis	---
Olecranon fossa (bony edge)	Anconeus	---
Lateral epicondyle	Common digital extensor Lateral digital extensor Ulnaris lateralis	---
Medial epicondyle	Pronator teres Flexor carpi radialis Flexor carpi ulnaris Superficial digital flexor Deep digital flexor (humeral)	---

Radius

CLASSIFICATION: Long bone

LOCATION: It lies between the humerus and the carpus. It is fused to the ulna along with two interosseus spaces.

DESCRIPTION

The radius is smaller of the two bones of the forearm. It extends in an oblique direction from the elbow. The distal end or trochlea is being nearer the median plane than the proximal end. It is gently curved; the convexity is being the cranial. It consists of a shaft and two extremities.

THE SHAFT

It is curved in its length, somewhat flattened cranio-laterally and widened at its both ends. However, it is more wider distally. It presents for description two surfaces and two borders.

The **CRANIAL SURFACE**is smooth, slightly convex in its length & rounded from side to side.

The **CAUDAL SURFACE**is correspondingly concave in its length and is flat in transverse direction. At its proximal part there is a smooth shallow groove, which concurs with the ulna in the formation of the interosseous space. A groove extends from this space laterally. The *nutrient foramen* is in the proximal part of this groove. Distal to this, there is in the young subjects a narrow, rough triangular area to which the ulna is attached by an interosseous ligament; in the adult the two bones are fused here.

The **MEDIAL BORDER**is largely subcutaneous; at its proximal end there is a smooth area.

The **LATERAL BORDER**presents no special features.

THE PROXIMAL EXTREMITY

It is flattened cranio-caudally and wide transversally. The proximal articular surface presents the humeral articular circumference, which corresponds to that of the distal end of humerus; it is crossed by a sagittal ridge. There are two concave facets for articulation with the ulna and between these.

The **INTEROSSEOUS SPACE** is a quadrilateral rough area at which the two bones are united by an interosseous ligament. At the medial side of the dorsal surface is the radial tuberosity.

The **MEDIAL TUBEROSITY** is continuous with radial tuberosity and gives attachment to short ligament of elbow.

The **LATERAL TUBEROSITY** is more salient; it gives attachment to the lateral collateral ligament of the elbow.

THE DISTAL EXTREMITY

It is also compressed cranio-caudally. It presents the carpal articular surface which consists of three facets. The distal extremity is large and is thickest medially. The carpal articular surface is oblique. The medial facet is the large and articulates with the radial carpal, the middle one articulates with the intermediate carpal bone. The lateral facet is the smallest one and articulates distally with the ulnar carpal and caudally with the accessory carpal bones.

The **CRANIAL SURFACE** presents three shallow grooves, separated by ridges; the medial one is vertical and gives passage to the tendon of the extensor carpi radialis. The medial one contains the common digital extensor tendon, lateral one is small and oblique; lodges the tendon of abductor digital longus (extensor carpi obliquus).

The **CAUDAL SURFACE** is crossed by a rough transverse crest, distal to which are three depressions. On each side is a tuberosity to which the collateral ligament is attached; the lateral one is marked by a small vertical groove for the passage of the tendon of lateral digital extensor.

MUSCLE ATTACHMENT

Bony Feature	Muscles originated	Muscles inserted
Coronoid process	---	Brachialis
Radial tuberosity	---	Biceps brachii
Medial border of radius	---	Pronator teres
Lateral border of radius	Extensor carpi radialis	---
Proximal extremity of radius	Deep digital flexor (radial head)	---

Ulna

CLASSIFICATION: Long bone

LOCATION: It is attached to the caudo-lateral surface of the radius in the forearm.

DESCRIPTION

Ulna is situated caudal to the radius, with which it is partially fused. It consists of a shaft and two extremities.

THE SHAFT

It is three sided in proximal third, compressed cranio-caudally in the middle third, and is rounded and expanded in the distal third. It presents two surfaces.

The cranial surface is applied to the caudal surface of the radius and there are two interosseous spaces. The surface, which enters into the formation of the said space, is smooth and usually presents a nutrient foramen. It is attached to the radius by an interosseous ligament.

The **MEDIAL SURFACE**.....is smooth and slightly concave.

The lateral is convex and is roughened proximally.

The **BORDERS, MEDIAL and LATERAL**.....are thin and sharp except at the interosseous space.

The **CAUDAL BORDER**is slightly concave in its length and is rounded.

The olecranon is the major part of this bone. It projects proximally and somewhat caudally and forms a lever. The free end or summit is a rounded rough tuberosity.

TROCHLEAR NOTCH

The cranial border bears on its middle a pointed projection, the *anconeal process* or “beak” which overhangs the trochlear notch. The latter is triangle in outline, concave proximodistally, convex transversally. It articulates with humerus; in its distal part there is an

extensive *synovial fossa*. Just distal to the notch are two convex facets, which have their counterparts on the caudal aspect of the proximal end of the radius.

MUSCLE ATTACHMENT

The proximal end presents a rounded tubercle, olecranon which is the basic bony feature.

Bony Feature	Muscles originated	Muscles inserted
Olecranon tubercle	---	Anconeus Tensor fascia antibrachii Triceps brachii (all heads)

Carpal Bones

CLASSIFICATION: A group of short bones

LOCATION: The carpus lies between the radius, ulna and the metacarpals.

DESCRIPTION

The carpus consists of six bones, four in the proximal row and two in the distal row. It is commonly and incorrectly called the “*knee*” in the animals. The bones are named and numbered as follows:

PROXIMAL ROW



PROXIMAL ROW

It is oblique in conformity with the carpal articular surface of the radius. The long axis of the radial and intermediate carpals is directed oblique palmerly and medially.

PECULIARITIES

The radial.....is narrow and palmerly it is curved proximally.
 The intermediate..... is constricted in its middle and is wider palmerly than dorsally.
 The ulnar carpal..... is larger and is very triangular. Its proximal surface is extensive and sinuous and form articulation with the radius. It has a large oval facet palmerly for articulation with the accessory carpal.
 The accessory carpal.....is short, thick and rounded. It articulates with the ulnar carpal only.

DISTAL ROW

PECULIARITIES

The first carpal is absent.
 The second and third carpal is fused to form a large quadrilateral bone.
 The fourth carpal is a small quadrilateral bone.

MUSCLE ATTACHMENT

Bony Feature	Muscles originated	Muscles inserted
Proximal border of Accessory carpal	----	Ulnaris lateralis Flexor carpi ulnaris

Metacarpal Bones

CLASSIFICATION: Long bones

LOCATION: The metacarpals are located between the distal row of the carpals and the proximal phalanx.

DESCRIPTION

The metacarpus consists of a large and a small metacarpal bone.

- The **LARGE METACARPAL BONE** results from the fusion of the third and fourth metacarpus of the fetus and bears evidence of its double origin even in the adult state.
- The **FIFTH METACARPAL BONE** is small cylindrical bone known as “splint bone”.
- The **FIRST** and **SECOND METACARPALS** are absent.

LARGE METACARPAL BONE

It is formed by the fusion of the Third and Fourth Metacarpals (Mc: III + IV)

DESCRIPTION

It presents a shaft and two extremities/ends for description.

THE SHAFT

The shaft is wider. It presents two surfaces and two borders.

The **DORSAL SURFACE** is rounded & is marked by a shallow vertical vascular groove, *dorsal longitudinal sulcus*.

The **PALMER SURFACE**..... presents a deep vertical vascular groove, *palmer longitudinal sulcus*.

The **MEDIAL** and **LATERAL BORDERS**are rough in the proximal third.

THE PROXIMAL END

The proximal end or base bears two concave facets for articulation with the distal row of the carpal bones.

The medial facet is somewhat larger and is separated by a ridge medially and a notch palmerly.

The palmero-lateral angle has a facet palmerly for articulation with the small metacarpal bone.

The medial part of the extremity has dorsal and palmer tuberosities.

THE DISTAL END

The distal end is divided into two parts by a *sagittal notch*.

Each division bears an articular surface which is further divided by a ridge.

The *medullary cavity* is divided into two parts by a vertical septum, which is usually incomplete.

MUSCLE ATTACHMENT

Bony Feature	Muscles originated	Muscles inserted
Proximal end or base	----	Extensor carpi obliquus Flexor carpi radialis
Metacarpal tuberosity	----	Extensor carpi radialis

SMALL METACARPAL BONE

It is assembled as the fifth metacarpal bone and is known as small metacarpal or splint bone.

DESCRIPTION

It is a long cylindrical, rounded rod which lies against the proximal part of the lateral border of the large bone in the form of a ridge.

THE EXTREMITIES

The **PROXIMAL END** articulates with the later, but not with the carpus.

The **DISTAL END** is pointed elsewhere.

Digits

In goat, four digits are present. Out of these four, only two; **THIRD (III)** and **FOURTH (IV)** are fully developed and has three phalanges and three sesamoids each.

The other two; **SECOND (II)** and **FIFTH (V)** are vestiges and are placed palmer to the fetlock as “dew-claw”. Each of these contains one or two small bones, which don’t articulate with the rest of the skeleton.

The **FIRST** digit is absent. Hence, each digit articulates with the metacarpal bone proximally.

MUSCLE ATTACHMENT

Bony Feature	Muscles originated	Muscles inserted
Extensor process of distal phalanx	----	Common digital extensor
Flexor tubercle of distal phalanx	----	Deep digital flexor (all heads)
Middle and distal phalanx	----	Lateral digital extensor Superficial digital flexor

.....

INTRODUCTION TO THE PELVIC LIMB

The pelvic limb, like the thoracic, consists of four segments, viz., the pelvic girdle, thigh, leg, and the pes.

1. PELVIC GIRDLE

The pelvic girdle consists of the oss coxae (or hip bones), the sacrum and the first three or more coccygeal vertebrae. The oss coxae consists originally three flat bones, i.e. ilium, ischium and pubis, which meet at acetabulum, a large cotyloid cavity with which the head of femur articulates.

2. THIGH

The thigh, like the arm, contains a single bone, the femur (or thigh bone). This articulates with the acetabulum above and the tibia and patella below.

3. LEG

The skeleton of the leg comprises three bones, viz. the tibia, fibula and patella.

The tibia and fibula are the long bones of the true leg (crus).

The patella (or knee-cap) is a large sesamoid bone which articulates with the trochlea of the distal end of the femur.

4. PES

The pes, the homologue of the foot of man, consists of three subdivisions;

a) TARSUS (or Hock)

It contains a group of short bones, the ossa tarsi. It includes,

- i) tibial and ii) fibular tarsals, iii) central / fourth tarsal (or Centro-quarter bone), iv) second / third tarsal. (“/” indicates the fusion of the described bones)

b) METATARSUS

The metatarsus resemble in general those of the corresponding regions of the thoracic limb. It comprises a large and a small metatarsal bone. The large metatarsal bone is formed by the fusion of the third and fourth metatarsals of the fetus. On the other hand, the small metatarsal bone is numbered as the second metatarsal.

c) DIGITS

The digits resemble in general those of the corresponding regions of the thoracic limb.

BONES OF THE PELVIC LIMB

Os coxae

The os coxae (or hip bone) is the largest of the flat bones.

It consists primarily of three parts(bones), viz. the ilium, ischium and pubis, which meet to form the acetabulum, a large cotyloid cavity with which the head of femur articulates.

ILIUM

Classification: Modified long bone.

Location: Cranial component of the pelvic girdle.

DESCRIPTION

The ilium is the largest of the three bones. The wide part of the bone is the wing that presents two surfaces. The body, is the constricted portion of the bone and is three sided (prismatic)

THE SURFACES

The gluteal surface is wide and concave. The wide part is crossed by the curved i) gluteal line, which runs parallel to the lateral border of the ilium.

The sacro-plevic surface (of wing) is convex and consist of two distinct parts; the caudal circular facet called i) the auricular face, articulates with the sacrum, and the cranial rough part. In case of shaft, it is smooth. The arcuate or ilio-pectineal line begins ventral to the auricular surface.

The lateral surface (of body or shaft) is convex and rough for attachment of muscles

THE BORDERS

The cranial border (or iliac crest) is thick and rough at cranial end and thin at caudal end.

The medial border is deeply concave and its middle part forms the greater ischiatic notch which is continuous caudally with the ischiatic spine.

The lateral border is concave in its cranial half and straight in its caudal half.

THE ANGLES

The lateral angle is the *tuber coxae*, which forms the basis of the points of the hip. It is large, thick and more pronounced, roughened for muscular attachment.

The medial angle is termed the tuber sacrale; it is thin, rough and truncated.

ISCHIUM

Classification: Modified long bone.

Location: It forms the caudal part of the ventral floor of the pelvis.

DESCRIPTION

The ischium is irregularly quadrangular, and presents two surfaces, four borders, and four angles. It consists of a body (ramus) and a tuber.

THE SURFACES

The pelvic surface is smooth and slightly concave from side to side.

The ventral surface is nearly flat, and in its greater part is roughened for muscular attachment.

THE BORDERS

The cranial border is forms the caudal margin of the obturator foramen.

The caudal border is thick and rough. It slopes medially and cranially to meet the border of the other side, forming with it the *ischiatic arch*.

The medial border meets the opposite bone at the *symphysis ischii*.

The lateral border is thick and rounded but concave in its length, forming the lesser ischiatic notch.

THE ANGLES

The cranio-lateral angle joins the other two bones at the acetabulum, of which it forms more than two half.

The cranio-medial angle meets the pubis with which it forms the medial boundary of the obturator foramen.

The caudo-lateral angle is thick rounded mass, the ischiatic tuberosity for attachment of muscles.

The caudo-medial angle joins its fellow at the symphysis.

PUBIS

Classification: Modified long bone.

Location: It is located cranial to the ischium. It also forms the cranial part of the pelvic floor.

DESCRIPTION

The pubis is the smallest of three bones of the os coxae. It may be described as having, a body, two branches two surfaces and three borders.

THE SURFACES

The pelvic surface is convex.

The ventral surface is convex and in great part rough for muscular attachment. Near the cranial border it is crossed by a pubic groove,

THE BORDERS

The cranial border is thin, and forms the pectin. Laterally it bears the rough iliopubic eminence, which is continuous with the arcuate line. Near the symphysis, there is a variable prominence, the *pubic tubercle*.

The caudal border forms the cranial margin of the obturator foramen.

The medial border joins the opposite bone at the symphysis pubis.

THE BRANCHES

The cranial branch joins the ilium and ischium at the acetabulum.

The caudal branch joins the ischium, with which it forms the inner boundary of the obturator foramen.

ACETABULUM

It is a cotyloid cavity, which lodges the head of the femur. It faces ventro-laterally.

PARTS

It consists of an (i) articular and a (ii) non-articular part.

The articular part (*facies lunata*) is crescentic and is cut internally by a rough non-articular depression, *acetabulum fossa*. The caudal part of the rim is correspondingly cut into a acetabular notch.

OBTURATOR FORAMEN

It is situated between the pubis and ischium on the floor of the pelvis.

It is oval in outline, the long axis being directed cranio-lateral, grooved cranio-laterally for the obturator vessels and nerves.

MUSCLE ATTACHMENT ON OS COAXE

Bony Feature	Muscles originated	Muscles inserted
Tuber coxae	Tensor fascia latae	----
Tuber ischii	Biceps femoris	----
	Semitendinosus	
	Semimembranosus	
Gluteal surface of ilium	Deep gluteal	----
Body (or shaft) of ilium	Middle gluteal	----

	Sartorius	
	Rectus femoris	
Cranial part of pubis	Pectineus	----
Prepubic tendon	Gracilis	----
Ventral surface of ischium	Adductor	----
	Quadratus femoris	

Femur

CLASSIFICATION: Long bone

LOCATION: It lies between the pelvis and the tibia and fibula.

DESCRIPTION

The femur extends obliquely, distally and cranially, articulating with the acetabulum proximally and the tibia and patella distally. It presents for description a shaft (or body), and two extremities.

THE SHAFT

It is generally cylindrical, but is flattened caudally and is smaller proximally than distally. It presents four surfaces, two borders.

The Surfaces

The cranial, medial and lateral surfaces are smooth and strongly convex from side to side.

The caudal surface is wide, flat and smooth in proximal $\frac{1}{4}$. Distal to this part, there is rough elevation for attachment of muscles. The middle third is narrower and rough also.

The Borders

The medial border bears on its proximal part a thick rough ridge, the lesser tubercle.

The lateral border is prominent throughout in its length. At the distal part, there is the supracondyloid fossa, which is bounded laterally by a thick, rough margin, called supracondyloid tuberosity.

THE PROXIMAL EXTREMITY

It is large and consists of the head, neck, and greater trochanter.

The head is placed at the medial side and is directed medially proximally and somewhat cranially. It is approximately hemispherical and is cut medially by a deep notch, the fovea capitis, in which the accessory ligament and the ligament of head of the femur are attached.

The neck is situated laterally.

THE DISTAL EXTREMITY

It is large in both directions comprises the trochlea cranially, and two condyles laterally.

The **TROCHLEA** consists of two ridges separated by a groove and forms an extensive surface for articulation with the patella. It is very unsymmetrical, the medial ridge is much wider, more prominent and extends higher than the lateral one.

The **CONDYLES**; medial and lateral are separated by the deep inter-condyloid fossa, and articulate with the condyles of the tibia and the menisci of the stifle joint.

The extensor fossa is situated between the lateral condyle and trochlae.

The inter-condyloid fossa lodges the inter-condyloid eminence of the tibia.

The Epicondyles

The medial epicondyle is a rounded prominence on the medial surface of the distal extremity.

The lateral epicondyle is less distinct.

MUSCLE ATTACHMENT

Bony Feature	Muscles originated	Muscles inserted
Greater trochanter	Vastus lateralis	Middle gluteal

Lesser trochanter	----	Quadratus femoris
Neck of femur		Deep gluteal
Caudal surface of femur	Vastus medialis	Adductor
Cranial, medial & lateral faces	Vastus intermedialis	----
Medial epicondyle		Pectineus
Lateral epicondyle	Popliteus	----
Extensor fossa	Long digital extensor Medial digital extensor Proneus tertius	-----
Supracondyloid fossa	Superficial digital flexor	-----
Supracondyloid tuberosity	Gastrocnemius	

Patella

The patella is a large sesamoid bone.

DESCRIPTION

The patella is a large sesamoid bone which articulates with the trochlea of the femur. It presents for description two surfaces, which are quadrilateral, convex and rough for muscular and ligamentous attachment. The articular surface is quadrilateral but much less extensive.

The **BORDERS**, medial and lateral, converge to the apex distally and each forms an angle at base.

The **BASE** faces proximally and caudally and is convex transversally, concave cranio-caudally. The **APEX** point directed distally.

MUSCLE ATTACHMENT

Bony Feature	Muscles originated	Muscles inserted
Base of patella	-----	Rectus femoris
Cranio-medial surface	-----	Vastus medialis Vastus intermedialis
Lateral surface	-----	Vastus lateralis
Medial patellar ligament	-----	Gracilis Sartorius

Tibia

CLASSIFICATION: Long bone.

LOCATION: It extends obliquely distally and caudally from the stifle to the hock.

DESCRIPTION

The tibia articulates with the femur proximally, and the tarsus distally. It presents for description a shaft and two extremities.

THE SHAFT

It is large and three sided (prismatic) proximally and is compressed from before backward distally.

The shaft is distinctly curved so that the medial side is convex in proximal, & concave in distal half.

It presents for description three surfaces, and two borders.

THE SURFACES

The **MEDIAL SURFACE** is broad proximally, and presents rough prominence for muscular attachment.

The **LATERAL SURFACE** is smooth and somewhat spiral. It is wide and concave in its proximal fourth, distal to which it becomes narrower and convex and widens gradually to the cranial part of bone.

The **CRANIAL SURFACE** is very prominent in its proximal third, forming the crest of tibia, and distally reduced to a rough line.

The **CAUDAL SURFACE** is in general smooth, and flattened triangular rough area in proximal third. The nutrient foramen is situated on the caudal surface or near the lateral border in the proximal third.

THE BORDERS

The **MEDIAL BORDER** is rounded in its proximal half in the form of a tubercle which gives attachment to the muscles. The distal part is a rough line on well-marked bones.

The **LATERAL BORDER** is concave in its proximal part and concurs with the fibula in the formation of the interosseous space.

THE PROXIMAL EXTREMITY

It is large and three sided. It bears two articular eminences, the *medial* and *lateral condyles*. Each presents a somewhat saddle-shaped surface for articulation with the corresponding condyle of the femur. The *inter-condyloid eminence* (or spine) is the central eminence, on either side (cranial and caudal) of it, is the *inter-condyloid fossa*. The condyles are separated by caudally by a deep popliteal notch. A semicircular smooth notch, the *sulcus muscularis* separates the tibial tuberosity from the lateral condyle.

The **LATERAL CONDYLE** has an overhanging lateral margin, distal to which there is a facet for articulation with the fibula.

THE DISTAL EXTREMITY

It is much smaller than the proximal one; it is quadrangular in form and larger medially than laterally. It presents an articular surface which is adapted to the trochlea of the talus.

The ridges and grooves are directed sagittal and are bounded on either side by the malleoli. The *medial malleolus* is more prominent. A shallow *synovial fossa* is usually present on the articular angle.

MUSCLE ATTACHMENT

Bony Feature	Muscles originated	Muscles inserted
Tibial tuberosity	-----	Quadriceps femoris
Proximal end	-----	Popliteus
Lateral condyle	Proneus longus Lateral digital extensor Cranial tibial Deep digital flexor	-----

Fibula

DESCRIPTION

The fibula usually consists of two ends (extremities) only.

PROXIMAL END (HEAD)

It is fused with the lateral condyle of the tibia and is continued by a small, blunt-pointed prolongation distally.

DISTAL END

It remains separate from the tibia and forms the lateral malleolus. The lateral malleolus rests on the calcaneus (fibular tarsal bone), and the medial one articulates with the lateral ridge of the talus.

MUSCLE ATTACHMENT

Bony Feature	Muscles originated	Muscles inserted
Head of fibula	Soleus	----

Tarsal Bones (Pes)

CLASSIFICATION: A group of short bones.

LOCATION: The tarsus lies between the tibia and fibula, and the metatarsals.

DESCRIPTION

The tarsus consists of six pieces; the central and fourth, and the second and third tarsal bones are fused whereas the fibular and tibial tarsal bones are separate.

Tibial Tarsal (Talus)

The talus is long & narrow; somewhat flattened dorso-plantarly. It bears a trochlea on either end.

PROXIMAL TROCHLEA

The grooves and ridges of the proximal trochlea are not spiral, but almost sagittal; the lateral ridge is wider and articulates with both the tibia and fibula.

DISTAL TROCHLEA

The distal trochlea consists of two condyles divided by a groove and articulates with the combined central+fourth tarsal.

THE SURFACES

The **LATERAL SURFACE** presents two facets for articulation with the calcaneus, and is excavated and rough elsewhere. The **MEDIAL SURFACE** bears a tuberosity at its proximal part, and is flattened distally.

Fibular Tarsal (Calcaneus)

The calcaneus is a long and slender bone.

The calcaneal tuber (tuber calcanii) is marked plantarly by a wide shallow groove.

Central and Fourth Tarsals

The central and fourth tarsal bones are fused to form a large centro-quartal bone, which extends across the entire width of the tarsus and articulates with all the other bones.

Second and Third Tarsals

The second and third tarsals are fused to form a rhomboid piece.

The **PROXIMAL SURFACE** is concave-convex, and articulates with the central component.

The **DISTAL SURFACE** is undulating and rests on the metatarsus.

MUSCLE ATTACHMENT

Bony Feature	Muscles originated	Muscles inserted
Tuber calcanii	----	Biceps femoris Semitendinosus Semimebrinosus Gastrocnemius Superficial digital flexor Soleus

Roughened faces of tarsals -----

Proneus longus
Cranial tibial

Metatarsal Bones

CLASSIFICATION: Long bones

LOCATION: The metatarsals are located between the tarsus and the proximal phalanx.

DESCRIPTION

The metatarsals consist of a large and a small metatarsal bone.

- The **LARGE METATARSAL BONE** results from the fusion of the third and fourth metatarsal of the fetus and bears evidence of its double origin even in the adult state.
- The **SECOND METATARSAL BONE** is small cylindrical bone known as "splint bone".
- The **FIRST and FIFTH METATARSALS** are absent.

LARGE METATARSAL BONE

The large metatarsal bone is about one-seventh longer than the corresponding metacarpal. It is formed by the fusion of the Third and Fourth Metatarsals (Mt: III + IV)

DESCRIPTION

It presents a shaft and two extremities/ends for description.

THE SHAFT

It is compressed transversally and is distinctly four sided.

The **DORSAL SURFACE** is rounded & is marked by a deep & wide vascular groove, *dorsal longitudinal sulcus*.

The **PLANTER SURFACE** presents a shallow vascular groove, *palmer longitudinal sulcus*. At this surface, there is proximal foramen which does not perforate the shaft, but passes obliquely through the extremity, opening on the caudal part of the proximal surface.

The **MEDIO-PLANTER ANGLE** presents a facet for articulation with the small metatarsal bone.

MUSCLE ATTACHMENT

Bony Feature	Muscles originated	Muscles inserted
Proximal end	-----	Proneus tertius Medial digital extensor

SMALL METATARSAL BONE

The small metatarsal bone is a quadrilateral disc a little less than an inch in width and height. Its cranial face bears a facet for articulation with the large metatarsal bone.

Digits

The phalanges and sesamoids resemble those of the thoracic limb so closely as to render separate description is unnecessary.

MUSCLE ATTACHMENT

Bony Feature	Muscles originated	Muscles inserted
Middle phalanx of third digit	----	Long digital extensor Lateral digital extensor
Flexor tubercle of third phalanx	-----	Deep digital flexor

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Chapter 5

ARTHROLOGY

Outline

- **Joint and uniting medium**
- **Classification of Joints**
- **Synarthroses**
 - **Classification**
- **Diarthroses**
 - **Structure of a Synovial joint**
 - **Movements of Synovial joints**
 - **Types of Synovial joints**
- **Amphiarthroses**
- **Joints of the Axial Skeleton**
- **Joints of the Appendicular Skeleton**

Syndesmology (arthrology) is the study of the articulations (unions) between bones, which are commonly called joints.

JOINT

An articulation or joint is formed by the union of two or more bones or cartilages or by other tissues.

Bone is the fundamental part of most of the joints. In some cases, a bone, and a cartilage, or two cartilages form a joint.

UNITING MEDIUM

The uniting medium is chiefly fibrous tissue or cartilage or a mixture of these.

CLASSIFICATION OF JOINTS

The joints may be classified;

- (a) **anatomically:**
 - according to their mode of development
 - nature of the uniting medium
 - form of the joint surfaces
- (b) **physiologically:**
 - with regard to the amount and kind of movement
 - with regard to the absence of motility in them.
- (c) by a combination of both (a) and (b) consideration.

There are three chief subdivisions are usually recognized;

- (i) Synarthrosis
- (ii) Diarthrosis
- (iii) Amphiarthrosis

SYNARTHROSES

They are often termed fixed or immovable joints

There is no joint cavity and most of the joints are temporary.

In this group, the segments are united by fibrous tissue or cartilage or both of these two.

CLASSIFICATION

The chief classes in this group of joints are as follows:

1. **Suture:** -----the term sutura is applied to those joints in skull in which the adjacent bones are closely united by fibrous tissue, called sutural ligament.
 - (i) *Sutura serrata*: In many cases, the edges of the bones have irregular interlocking margins. e.g. frontal suture
 - (ii) *Sutura squamosa*: the edges are beveled and overlap. e.g. parieto-temporal suture.
 - (iii) *Sutura hormonia*: the edges are plane or slightly roughened. e.g. nasal suture.
2. **Syndesmosis:** It refers to a joint united by a white fibrous or elastic tissue or a mixture.e.g. union of the shafts of the metacarpal bones, attachment of costal cartilages to each other.
3. **Symphysis:** It is an immovable joint in which the uniting medium is hyaline cartilage.e.g. joint between the basilar part of the occipital bone and the sphenoid bone. Very few of such joints are permanent.
4. **Symphysis:** the term is usually limited to a few median joints which connect symmetrical parts of the skeleton. e.g. symphysis pelvis, symphysis mandibulae
5. **Gomphosis:** The term is sometimes applied to the implantation of the teeth in the alveoli (socket). The gomphosis is not, properly considered a joint at all since the teeth are not the parts of the skeleton.

DIARTHROSIS

They are often called *movable, true joints* or *synovial joints*.

These joints are characterized by:

- (i) the presence of a joint cavity with a synovial membrane in the joint capsule
- (ii) their mobility.

STRUCTURE OF A SYNOVIAL JOINT

A simple joint is formed by two articular surfaces; whereas a composite joint formed by several articular surfaces. The following structures involve into their formation:

- 1) Articular surfaces
- 2) Articular cartilages
- 3) Articular or joint capsule
- 4) Ligaments
- 5) Articular discs or menisci
- 6) Marginal cartilage

1) Articular surfaces: are in most cases smooth, and very much in form.

- They are formed of especially dense bone, which differ histologically from ordinary compact substance.

- In certain cases, the surface is interrupted by non-articular cavities, known as *synovial fossa*.

2) Articular cartilages: are usually hyaline in type & form a covering over the articular surfaces of bones.

- They vary in thickness in different joints; thickest on these which are subjected to most pressure & friction.

- They usually tend to accentuate the curvature of the bone.

- They are non-vascular, very smooth and have a bluish tinge in the fresh state.

- They diminish the effects of the concussion and greatly reduce the friction.

3) Articular or Joint capsule: is in its simplest form, a tube, the ends of which are attached around the articulating surfaces.

- It consists of two layers. The deeper layer is the (i) *synovial membrane*, a delicate layer of specialized connective tissue extending from the edges of the articular cartilages of the

adjacent bones but not covering the articular cartilage. The membrane secretes a the *synovial fluid (synovia)*. It lubricates the normal joint. The surface of synovial membrane is increased by folds (*plicae synoviales*) and villi which contain fat pads and which project into the cavity. The superficial layer of the joint capsule is the (ii) *fibrous membrane*, a heavier fibrous sleeve adjacent to the synovial membrane.

4) Ligaments: are strong bands or membranes, usually composed of white fibrous tissue and function to bind the bones together. They are pliable, but practically inelastic.
- In a few cases, however, e.g. the *ligamentum nuchae*, they are composed of elastic tissue.

5) Menisci (Articular discs): are plates of fibrocartilage or dense fibrous tissue placed between the articular cartilages, and divided the joint cavity partially or completely into two compartments.

- They contribute to the congruency of the articular cartilages and probably play a role in complex joint movements. Prominent menisci are found in the stifle and the temporomandibular joint.

6) Marginal cartilage: is a ring of fibro-cartilage which encircles the rim of an articular cavity.

- It enlarges the cavity and tends to prevent the fracture of the margin.

TYPES OF MOVEMENTS

Synovial (formerly called diarthrodial) joints may exhibit one or more of the following movements;

- (i) **Gliding or sliding:** such type of movement refers to the sliding of one practically plane on the other. E.g. Joint between the articular surfaces of the cervical vertebrae.
- (ii) **Flexion:** is the movement that tends to decrease the angle segments making up a joint.
- (iii) **Extension:** is the reverse of flexion and is movement that tends to increase the angle between the segments forming the joints.
- (iv) **Circumduction:** combines the other type of rotation except rotation. It designates movement in which the distal end of the limb describing a circle.
- (v) **Rotation:** this term is reserved to indicate rotation of one segment around the longitudinal axis of the other segment forming the joint. E.g. Atlanto-axial joint.
- (vi) **Adduction:** it is the movement of an extremity towards the median plane.
- (vii) **Abduction:** is the movement of an extremity away from the median plane.

TYPES OF SYNOVIAL JOINTS

The synovial joints are classified according to the type of joint surface and movements. The following chief types may be recognized.

- (i) **Arthrodia (gliding) Joints:** in these, the surfaces are practically flat, admitting of gliding movement. E.g. (i) Carpo-metacarpal joint. (ii) Joint between articular processes of cervical and thoracic vertebrae.
- (ii) **Ginglymus (hinge) Joints:** the joint surfaces consist usually of two condyles, or of a segment of a cylinder or cone, which are received by corresponding cavities. E.g. (i) Atlanto-occipital joint (ii) Elbow joint.
- (iii) **Trochoid (pivot) Joints:** in these, the movement is limited to rotation of one segment around the longitudinal axis of the other. E.g. (i) Atlanto-axial joint.
- (iv) **Enarthrosis (ball and socket) Joints:** these are formed by a surface of approximately spherical curvature, received into a corresponding cavity. They are multiaxial and allow greatest variety of movement. E.g. (i) Hip joint (ii) Shoulder joint.

AMPHIARTHROSIS

These joints, as the name indicates, share some characters with both of the preceding groups.

In them, the segments are directly united by a plate of fibrocartilage and usually by ligaments also.

The amount and kind of the movement are determined by the shape of the joint surfaces and the amount and pliability of the uniting medium.

These joints are nearly all medial in position, and are best illustrated by the joints between the bodies of the vertebrae. There is typically no joint cavity, but in certain situations, only one exists.

JOINTS OF THE AXIAL SKELETON

Name	Formed by.....	Classified as.....
Symphysis mandibulae	The bodies of the rami of mandible	Synarthroses > Symphysis
Temporo-mandibular Joint	i) Mandible ii) Temporal bone of the skull	Diarthroses > Condylar joint
Atlanto-occipital Joint	i) Atlas (First cervical vertebra) ii) Occipital bone of the skull	Diarthroses > Ginglymus joint
Atlanto-axial Joint	i) Atlas (First cervical vertebra) ii) Axis (Second cervical vertebra)	Diarthroses>Trochoid joint
Intercentral articulations	Extremities of the bodies of two adjacent vertebrae	Amphiarthroses
Interneural articulations	Articular processes of two adjacent vertebrae	Diarthroses
Costo-central articulation	i) Head of the rib ii) Bodies of two adjacent vertebrae	Diarthrosis >Trochoid (pivot)joint
Costo-transverse articulation	i) Tubercle of the rib ii) transverse process of the vertebra	Diarthroses > Gliding joint
Costo-chondral articulation	i) Sternal end of the rib ii) Costal cartilage	Synarthroses
Chondro-sternal articulation	i) Cartilages of the asternal ribs ii) The sternum	Diarthroses

JOINTS OF THE APPENDICULAR SKELETON

Name	Formed by	Classified as
Shoulder (scapulo-humeral) Joint	i) distal end of the scapula ii) Proximal end of the humerus	Diarthroses > Ball and socket joint
Elbow Joint	i) Distal extremity of humerus ii) proximal end of radius & ulna	Diarthroses > Ginglymus
Carpal (knee) Joint	i) radio-carpal joint: the distal end of radius and proximal row of carpus ii) Intercarpal joint: between two rows of carpus iii) carpo-metacarpal joint: the distal rwo of carpus and proximal ends of metacarpus.	Diarthroses > i) & ii) Ginglymus and iii) Arthrodial (gliding) joint
Fetlock Joint	Distal end of the large metacarpal, the proximal end of first phalanx and the proximal sesamoid bones.	Diarthroses > Ginglymus

Pastern Joint	Distal end of first phalanx and proximal end of second phalanx.	Diarthroses > Ginglymus
Coffin Joint	Distal end of second phalanx, proximal end of third phalanx and distal sesamoid bones.	Diarthroses > Ginglymus
Sacro-iliac articulation	The auricular surfaces of the sacrum and ilium.	Diarthroses
Symphysis pelvis	The two ossa coxarum at ventral median line.	Synarthroses > Symphysis
Hip Joint	Proximal end of the femur and the acetabulum	Diarthroses > Ball and socket joint
Stifle Joint	i) femoro-patellar joint : trochlea of the femur and articular surface of patella. ii) femoro-tibial joint : condyles of the femur and proximal end of tibia.	Diarthroses > Ginglymus
Tarsus (Hock) Joint	Same as carpal joint, consists of three chief joints. I) tibio-tarsal joint ii) inter-tarsal joint iii) tarso-metatarsal	Diarthroses > Ginglymus

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Chapter 6

MYOLOGY

Outline

Introduction to Myology

Naming of Skeletal Muscles

Muscles of the thoracic limb

- Extrinsic muscles
- Muscles of shoulder
- Muscles of arm
- Muscles of forearm

Muscles of the pelvic limb

- Muscles of hip and thigh
- Muscles of leg and foot

Muscles of the face

- Mandibular muscles

Muscles of the neck

Muscles of the thorax

Muscles of the back and loin

Muscles of the abdomen

Muscles of the tail

INTRODUCTION TO MYOLOGY

Myology deals with the muscles and their structures.

PROPERTIES OF MUSCLES

- ▶ The muscles are highly specialized organs, which are characterized by their property of contracting in a definite manner when stimulated.
- ▶ They are the active organs of motion.
- ▶ The contractile part of the muscle is the muscular part.

KINDS OF MUSCULAR TISSUE

Three kinds of muscular tissue are recognized; viz.

1. Striated or striped:
2. Non-striated, unstriped or smooth:
3. Cardiac; which may be regarded as a specialized variety of striated muscle.

DESCRIPTION OF THE MUSCLES

The description of the muscles may be arranged under the following heads;

1. Name
2. Shape and position
3. Attachments
4. Action
5. Structure
6. Relations
7. Blood and nerve supply

BASIC TERMINOLOGY

1. Origin:

The term 'origin' is applied to the attachment which always or more commonly remains stationary when the muscle contracts.

2. Insertion:

The term 'insertion' is applied to the more movable attachment of the muscle.

3. Tendon:

A tendon is a band of dense white fibrous tissue by means of which a muscle is attached.

4. Aponeurosis:

It is a broad fibrous sheet which fulfils a similar function (as like that of tendon).

NAMING OF SKELETAL MUSCLES

Name	Shape	Size	Number of heads or bellies	Position	Attachment	Actions
Deltoideus	Triangular					
Teres	Round					
Rectus	Straight					
Major		Large				
Longissimus		Broadest				
Latissimus		Longest				
Biceps			Two heads			
Quadriceps			Four heads			
Digastricus			Two bellies			
Pectoral				Of chest		
Supraspinatus				Above spine		
Brachii				Of the arm		
Brachiocephalicus					From arm to skull	
Coracobrachialis					From coracoid process -arm	
Extensor						Extend
Flexor						Flex
Pronator						Pronate

These names are commonly used in combination; for example long digital extensor (Long extensor of digit).

MUSCLES OF THE THORACIC LIMB

EXTRINSIC MUSCLES

Name of the Muscle	Origin	Insertion
Trapezius	Spine of cervical and thoracic vertebrae.	Spine of scapula
Omo-transversarius	Wing of atlas	
Rhomboideus	Dorsal midline, both cranial and caudal to the scapula	Scapular cartilage

Serratus ventralis	(i) Transverse process of last 4-5	
(i) Cervical part	CV	Serrated facies of scapula
(ii) Thoracic part	(ii) lateral surface of first 8-9 ribs	
Latissimus dorsi	Thoraco-lumber fascia	Teres major tuberosity
Brachiocephalicus		
i) cleido-occipitalis	i) occipital bone of skull	
ii) cleido-mestoideus	ii) mastoid process	Crest of humerus
Superficial pectoral	Medial raphae and ventral	
Deep pectoral	surface of sternum	Fascia over lesser tubercle

MUSCLES OF THE SHOULDER

a) Lateral Muscles

Supraspinatus	Supraspinous fossa	Anterior part of proximal tuberosities of humerus
Infraspinatus	Infraspinous fossa	Greater tubercle of humerus
Deltoides	Acromion process of scapula	Deltoid tuberosity
Teres minor	Caudal border of scapula	Greater tubercle (caudal end)

b) Medial Muscles

Subscapularis	Subscapular fossa of humerus	Lesser tubercle of humerus
Teres major	Caudal border of scapula	Teres tuberosity of humerus
Coraco-brachialis	Coracoid process of scapula	

MUSCLES OF THE ARM

Biceps brachii	Supraglenoid tubercle of scapula	Radial tuberosity of radius
Brachialis	Posterior surface of humerus	Coronoid process of radius
Tensor fascia antibrachii	Caudal border of scapula	
Triceps brachii		
a) Long head	a) Caudal border of scapula	Olecranon
b) Medial head	b) Medial surface of humerus	
c) Lateral head	c) Deltoid tuberosity	
Anconeus	Olecranon fossa (bony edge)	

MUSCLES OF THE FOREARM

a) Extensor Division

Extensor carpi	Radial fossa and lateral	Metacarpal tuberosity
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radialis	epicondyle of humerus	
Common digital extensor		Extensor process of distal phalanx of 3 rd and 4 th digits.
Lateral digital extensor	Lateral epicondyle of humerus	2 nd and 3 rd phalanx of 4 th digit.
Extensor carpi obliquus	Lateral border of radius	Proximal end of large metacarpal

b) Flexor Division

Ulnaris lateralis	Lateral epicondyle of humerus	Accessory carpal bone
Pronator teres		Medial border of radius
Flexor carpi radialis	Medial epicondyle of humerus	Proximal end (large metacarpal)
Flexor carpi ulnaris		Accessory carpal bone
Superficial digital flexor		2 nd phalanx of 3 rd and 4 th digit
Deep digital flexor		
i) humeral head	i) medial epicondyle of humerus	Flexor tubercle of distal phalanx
ii) radial head	ii) proximal end of radius	
iii) ulnar head	iii) proximal end of ulna	

ACTION

Action	Name of Muscle
To draw the scapula cranially and caudally	Trapezius
To draw the scapula dorsally and ventrally	Rhomboideus
To pull the limb cranially and caudally	Serratus ventralis
To move the head and neck laterally	Omo-transversarius Brachiocephalicus
To adduct the forelimb	Superficial pectoral Deep pectoral Subscapularis
To abduct the forelimb	Deltoideus
Muscles Acting on Shoulder	
To extend the shoulder joint	Supraspinatus
To flex the shoulder joint	Latissimus dorsi Teres major et minor Infraspinatus Coraco-brachialis
Muscles Acting on Elbow	

To extend the elbow joint	Triceps brachii (all heads) Tensor fascia antibrachii Anconeus
To flexor the Elbow joint	Biceps brachii Brachialis Pronator teres
Muscles Acting on Carpal	
To extend the carpal joint	Extensor carpi radialis Extensor carpi obliquus
To flex the carpal joint	Flexor carpi radialis Flexor carpi ulnaris Ulnaris lateralis
Muscles Acting on Digit	
To extend the digit	Common digital extensor Lateral digital extensor
To flex the digit	Superficial digital flexor Deep digital flexor

MUSCLES OF THE PELVIC LIMB

MUSCLES OF HIP AND THIGH

a) Lateral Muscles

Name of the Muscle	Origin	Insertion
Tensor fascia latae	Tuber coxae	Indirectly to patella and tibia
Middle gluteal	Gluteal surface of ilium	Greater trochanter of femur
Deep gluteal	Body of the ilium and ischium	Neck of the femur
Biceps femoris		
Semitendinosus	Tuber ischii	Tuber calcanii
Semimebranosus		

b) Medial Muscles

Sartorius	Body of ilium	Medial patellar ligament
Gracilis	Prepubic tendon	
Pectineus	Pectin of pubis	Medial epicondyle of femur
Adductor	Ventral surface of ischium	Caudal surface of femur
Quadratus femoris		Lesser trochanter of femur

c) Cranial Muscles

Rectus femoris	Body of ilium	
Vastus lateralis	Greater trochanter of femur	
Vastus medialis	Neck & caudal surface of femur	Patella and tibial tuberosity
Vastus intermedialis	All surfaces except caudal of femur	

MUSCLES OF THE LEG AND FOOT

a) Dorso-lateral Muscles

Long digital extensor		Second phalanx of 3 rd digit
Proneus tertius	Extensor fossa of femur	Proximal end of large metatarsal
Medial digital extensor		
Lateral digital extensor		Second phalanx of 3 rd digit
Proneus longus	Lateral condyle of tibia	First tarsal bone
Cranial tibial		First to third tarsals

b) Planter Muscles

Gastrocnemius	Supracondyloid tuberosity	
Superficial digital extensor	Supracondyloid fossa of femur	Tuber calcanii
Soleus	Head of fibula	
Deep digital flexor	Lateral condyle of tibia	Flexor tubercle of distal phalanx
Popliteus	Lateral epicondyle of femur	Proximal end of tibia

ACTION

Action	Name of Muscle
To adduct the hind limb	Sartorius Gracilis Pectineus Adductor Quadratus femoris
To abduct the hind limb	Deep gluteal
Muscles Acting on Hip	
To extend the hip joint	Middle gluteal Biceps femoris Semitendinosus Semimembranosus

To flex the hip joint	Tensor fascia latae
Muscles Acting on Stifle	
To extend the stifle joint	Rectus femoris Vastus medialis Vastus intermedialis Vastus lateralis
To flex the stifle joint	Gastrocnemius
Muscles Acting on Hock	
To extend the hock joint	Gastrocnemius
To flex the hock joint	Proneus tertius Proneus longus Cranial tibial Popliteus
Muscles Acting on Digit	
To extend the digit	Long digital extensor Medial digital extensor Lateral digital extensor
To flex the digit	Superficial digital flexor Deep digital flexor
Muscle Assisting the other Muscle	
To assist the Gastrocnemius	Soleus

MUSCLES OF THE FACE

Name of Muscle	Origin	Insertion
Orbicularis oris	Margins of the lips	No direct attachment
Levator nasolabialis	Rostral part of frontal bone	Nostrils and maxillary lip
Caninus		Lateral walls of nostrils
Levator maxillaris	Facial tuberosity	Maxillary lip
Depressor labi maxillaris		
Depress. labi mandibularis	Alveolar border of maxilla	Mandibular lip
Buccinator	and mandible	Angle of the mandible
Dilator nares apicalis	Body of premaxilla	Ventral portion of nostrils
Zygomaticus	Masseteric fascia	Commissure of the lips
Mentalis	Body of mandible	Skin of the chin
Malaris	Lacrimal fascia	Buccal fascia
Orbicularis oculi	Skin of the eyelids	Medial canthus of the eye
Frontalis	Base of the horns	Forehead region

MANDIBULAR MUSCLES

Masseter	Facial tubercle and ventral surface of zygomatic arch	Masseteric fossa of mandible
Teemporalis	Temporal fossa	Coronoid process of mandible
Pterygoideus medialis	Pterygo-palatine fossa	Medial surface of mandible
Pterygoideus lateralis		
Digastricus	Paramastoid process	Medial surface of mandible

ACTION

Action	Name of Muscle
To dilate the nostrils	Levator nasolabialis Caninus Dilator nares apicalis
To retract the angle of the mouth	Buccinator Zygomaticus
To raise the skin to which it is attached	Mentalis
Muscles Acting on Lips	
To close the lips	Orbicularis oris
To retract the rostral lip	Depressor labii maxillaris
To retract the mandibular lip	Depressor labii mandibularis
Muscles Acting on Eyelids	
To close the eyelids	Orbicularis oculi
To elevate the upper eyelid	Frontalis
To depress the lower eyelid	Malaris
Muscles Acting on Mandible	
To bring the Jaws together	Masseter
To raise the lower jaw (mandible)	Temporalis
To depress the lower jaw (mandible)	Digastricus
To move the rami towards the median plane	Pterygoideus medialis
To move the rami towards the lateral side	Pterygoideus lateralis

MUSCLES OF THE NECK

VENTRAL CERVICAL MUSCLES

Name of Muscle	Origin	Insertion
Cutaneous colli	It is a ventral medial connective tissue strip of the neck	

Brachiocephalicus		
i) Cleido-occipitalis	i) occipital bone	Crest of humerus
ii) Cleido-mastoideus	ii) Mastoid process	
Sternocephalicus		
i) Sternomastoideus	Manubrium of sternum	i) Mastoid process
ii) Sternomandibularis	(first sternebrae)	ii) ventral border of mandible and zygomatic arch
Sternothyrohyoideus		
		Thyroid cartilage
Omohyoideus	Transverse process of 3 rd -4 th CV	Basihyoid bone
Scalenus	Transverse process of 3 rd -7 th CV	First and second rib

DORSO-LATERAL CERVICAL MUSCLES

Name of Muscle	Origin	Insertion
Longissimus capitis et atlantis	Transverse process of first 2 TV	Lateral borders of atlas
Rectus capitis dorsalis major	Spine of axis	Occipital bone
Rectus capitis dorsalis minor	Dorsal arch of atlas	
Rectus capitis lateralis	Dorsal arch of atlas	Mastoid and paramastoid processes
Obliquus capitis anterior	Cranial border of wing of atlas	
Obliquus capitis posterior	Spine of axis	Dorsal surface of wing of atlas
Splenius	Spinous process of first 4 TV	Transverse p. of 2 nd to 5 th CV
Multifidus cervicis	Articular processes of last 5 CV	Spinous & articular processes of CV

ACTION

Action	Name of Muscle
Muscles Acting on Neck and Head	
To elevate the head and neck	Splenius
To extend the head and neck	Longissimus capitis et atlantis Complexus Rectus capitis dorsalis major
To extend the head	Rectus capitis dorsalis minor Obliquus capitis anterior
To extend the atlanto-axial joint	Obliquus capitis posterior
To flex the head and neck	Sternocephalicus Rectus capitis ventralis major Longus colli Intertransversalis colli

To flex the neck	Scalenus
To flex the atlanto-occipital Joint	Multifidus cervicis Rectus capitis ventralis minor
Muscles Acting on Hyoid and Tongue	
To retract the hyoid bone and tongue	Sterno-thyrohyoideus Omo-hyoideus

MUSCLES OF THE THORAX

Name of Muscle	Origin	Insertion
Levator costarum	Transverse processes of TV	Cranial border of succeeding rib
External intercostals	Caudal border of all ribs	
Internal intercostals	Cranial border of all ribs	Caudal border of succeeding ribs
Retractor costae	Transverse process of first 3 LV	Caudal border of last rib
Rectus thoracis	Caudo-lateral surface of first rib	Costal cartilages
Transversus thoracis	Sternal ligament	
Serratus dorsalis cranialis	Thoraco-lumbar fascia	Cranio-lateral surface of 6-8 ribs
Serratus dorsalis caudalis		Caudal border of last 3 ribs

ACTION

These muscles are also called the *muscles of respiration*.

Action	Name of Muscle
To aid in inspiration	Levator costarum External intercostal Rectus thoracic
To aid in expiration	Internal intercostals Transverses thoracic
To aid in forced expiration (by retraction of last rib)	Retractor costae

MUSCLES OF BACK AND LOIN

Name of Muscle	Origin	Insertion
Serratus dorsalis cranialis	Thoracolumbar fascia	Cranio-lateral surface of 6-8 ribs
Serratus dorsalis caudalis		Caudal border of last 3 ribs
Longissimus dorsi	Ventral surface of ilium	Transverse and spinous p. of TV
Longissimus costarum	Lumbo-dorsal fascia	Caudal border of ribs
Multifidus dorsi	Lateral wings of sacrum	Spinous process of sacral, lumbar, thoracic and last CV.
Intertransversarii	Caudal border of last 3	-----

lumborum	ribs
----------	------

ACTION

Action	Name of Muscle
To aid in inspiration	Serratus dorsalis anterior Serratus dorsalis posterior
To aid in expiration (To retract and depress ribs)	Longissimus costarum (Ilio-costalis)
Most powerful extensor of back and loin	Longissimus dorsi
To flex the loin (lumbar region)	Intertransversalis lumborum
To extend the spine	Multifidus dorsi

MUSCLES OF THE ABDOMEN

Name of Muscle	Origin	Insertion
External abdominal obliquus	Caudo-lateral surface of ribs	Linea alba and prepubic tendon
Internal abdominal obliquus	Deep lumbar fascia	
Transverses abdominis	Deep para-lumbar fascia	Linea alba
Rectus abdominis	Ventral surface of sternum	Prepubic tendon

ACTION

Action	Name of Muscle
To support and compress the abdominal viscera	External abdominal obliquus Internal abdominal obliquus Transverses abdominis Rectus abdominis

MUSCLES OF THE TAIL

Name of Muscle	Origin	Insertion
Sacro-coccygeus dorsalis	Sacral spines	Dorsal surface of coccygeal vert.
Sacro-coccygeus lateralis	Caudal art. Processes of 5 th and Cranial art. Processes of 6 th LV	Spine of 3 rd coccygeal vertebrae
Sacro-coccygeus ventralis	Ventral surface of sacrum	Ventral surface of Cy vertebrae
Intertransversales caudae	Lateral edge of sacrum	Transverse process Cy vertebrae

Recto-coccygeus	Sacro-sciatic ligament	First 4 Cy vertebrae & Cy fascia
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ACTION

Action	Name of Muscle
To extend the tail	Sacro-coccygeus dorsalis Sacro-coccygeus lateralis
To flex the tail	Scaro-coccygeus ventralis Recto-coccygeus
To assist in lateral flexion of the tail	Intertrasversalis caudae

.....

Chapter 7

RESPIRATORY SYSTEM

Outline

Elements of Respiratory System

- Nostrils
- Nasal Cavity
- Larynx
- Trachea
- Bronchi
- Lungs

Relevant Structures

- Thoracic cavity and Mediastinum
 - Diaphragm
 - Pleura
-

This is the system by which the body tissues take up oxygen and dispose of carbon dioxide. Delivering oxygen and removing carbon dioxide (the product of cellular respiration) are the two main functions of this system.

ELEMENTS OF RESPIRATORY SYSTEM

The respiratory system consists essentially of the lungs and the passages that conduct air into and out of the lungs. These passages include: the nostrils, nasal cavity, pharynx (see chapter 9), larynx, trachea and bronchi (sing. bronchus).

RELEVANT STRUCTURES

Thoracic cavity and Mediastinum, diaphragm, and pleura.

NOSTRILS

The *external nares* or *nostrils* are the external openings of the respiratory tract. These slit-shaped nostrils are bounded by the medial and lateral *alae* (simply called the *wings*). The wings meet dorsally and ventrally to form *commissures* or *angles*.

NASAL CAVITY

Nostrils lead to the nasal cavity. The nasal cavity is separated from the mouth by the hard and soft palates. It is divided into two halves by the *median nasal septum* and *vomer bone*. All the facial bones except mandible and hyoid, enclose the nasal cavity.

..... (See Figure 7 -1)

BONES

The greater part of each half of the nasal cavity is occupied by the *conchae* (turbinate bones); viz.

- Dorsal concha
- Ventral concha
- Ethmoidal concha (Ethmo-turbinate bone)

The mucus membrane investing this bone is the olfactory epithelium.

MEATUSES

The conchae form many passages throughout the cavity, called **meatuses**.

i. Dorsal Nasal Meatus

It is situated between the roof of the cavity and dorsal concha.

ii. Middle Nasal Meatus

It is situated between the dorsal conchae and ventral conchae.

iii. Ventral Nasal Meatus

It lies between ventral concha and floor of the nasal cavity.

iv. Common Nasal Meatus

It is a narrow passage which is situated between the median nasal septum and concha.

Choanae or Posterior nares: are two elliptical orifices by which the nasal cavity and pharynx communicate. They are in the same plane as the floor of the nasal cavity, and are separated from each other by the vomer bone.

LARYNX

The larynx is a short, but complex valvular apparatus which regulates the volume of air passes through the tract, prevents aspiration of foreign material and, as it contains the **vocal cords**, is the chief organ of voice.

LOCATION

It lies caudal to the ramus of the mandible.

RELATIONS

It is related dorsallyto the pharynx and the origin of the esophagus. Ventrallyit is covered by the skin, fascia, and sterno-hyoid and omo-hyoid muscles. Laterallyit is related to the parotid and mandibular glands.

CARTILAGES OF LARYNX

The skeleton of the larynx consists of a framework of cartilages, which are connected by joints, and ligaments or membranes, and moved by extrinsic and intrinsic muscles. It is lined by mucous membrane.

..... (See Figure 7 – 2)

There are four cartilages in which one is **paired** while the other three are **unpaired**.

TABLE 7 – 1: DESCRIPTION OF LARYNGEAL CARTILAGES

Type	Cartilages	Shape	Location	Features / Parts
Unpaired	Cricoid	Like signet ring	Rostral to first tracheal ring	Dorsal lamina, lateral and ventral arch
	Thyroid	U- shaped	----	Ventral body and two lateral lamina
	Epiglottis	Cordate leaf-like	Above the body of the thyroid.	Base, apex, two surfaces (lingual and laryngeal) and two lateral borders
Paired	Arytenoid	Three sided pyramid	On either side, rostral to lamina of cricoid	A rostral apex and a caudal base

TRACHEA

The **trachea** or **windpipe** is a patent, flexible, cartilaginous and membranous tube for passage of air to and from the lungs. It is kept permanently open by a series of incomplete cartilaginous rings embedded in its wall.

COURSE

The trachea occupies a median position, except near its termination, where it is pushed a little to the right by the arch of the aorta.

LOCATION

The trachea extends caudal to the larynx at the level of 2nd cervical vertebrae to the roots of the lungs opposite to the 5th thoracic vertebrae where it bifurcates into *right* and *left bronchi*.

TABLE 7 – 2: REPRESENTATIVE VALUES FOR TRACHEA

Average Length of Trachea	22-25 cm
Caliber of Trachea	1.5 cm
Total number of Cartilaginous rings	48 – 60

PARTS

The trachea is divided into two parts;

- i. Cervical part
- ii. Thoracic part

i. Cervical Part

In this region, the outline of cartilaginous ring is U-shaped which is roofed up by the *trachialis* muscle.

RELATIONS

In its cervical part, the trachea is related dorsally to the esophagus for a short distance, but chiefly to the longus colli muscles. The sterno-hyoideus muscle lies on the ventral surface.

ii. Thoracic Part

It lies in the cranial and middle mediastinum.

In this region, the cartilaginous rings are bent to form ridge dorsally.

RELATIONS

It is related dorsally to the *longus colli* for a short distance, and beyond this to the esophagus. Ventrally it is related to the anterior vena cava, the brachiocephalic and common carotid trunks, and the cardiac and left recurrent nerves.

BRONCHI

There are three bronchi formed by the bifurcation of trachea.

Right and *left bronchi* are formed by the bifurcation of trachea opposite to the 5th rib.

In addition to right bronchi, 3rd or special, is also supplied to the apical lobe of the right lung.

Special or *3rd bronchus* is aroused from the trachea opposite to the 3rd rib.

DIFFERENCE BETWEEN A BRONCHUS AND TRACHEA

The structure of bronchus is almost similar to that of trachea but the cartilaginous framework consists chiefly of plates instead of rings.

THORACIC CAVITY & MEDIASTINUM

THORACIC CAVITY

It is second in point of size in all the body cavities. In form, it is somewhat like a truncated cone, much compressed laterally in its anterior part, and with the base cut off very obliquely.

BOUNDARIES

The **dorsal wall** is formed by Thoracic vertebrae

The **lateral walls** are formed by Ribs

The **ventral wall** is formed by Sternum

The **posterior wall** is formed by Diaphragm

The **anterior aperture** is occupied by Thoracic inlet

THORACIC INLET

The **thoracic inlet** (anterior aperture or inlet) is small, and of narrow, oval form. It is bounded dorsally by the first thoracic vertebra and laterally by the first pair of ribs. It is occupied by the longus colli muscles, the trachea, esophagus, vessels, nerves, and lymph glands. The **HEIGHT** of thoracic inlet is about 7.5 – 10 cm and its greatest **WIDTH** is about ...5 cm.

MEDIASTINUM

The mediastinum is the median septum of the thorax between the two lungs. It includes the mediastinal pleura.

DIVISION

For descriptive purposes, the mediastinum is divided into three subdivisions; viz.

- i) Anterior mediastinum
- ii) Middle mediastinum
- iii) Posterior mediastinum

DIAPHRAGM

The diaphragm is a broad, unpaired, dome shaped muscle which forms a partition between **thoracic** and **abdominal cavities**. It is the chief muscle of respiration.

DIVISION

The diaphragm consists of two parts; viz.

- i. **Muscular Part:** it is opaque in appearance and extends toward the peripheral region.
- ii. **Tendinous Part:** It is transparent in appearance and located centrally.

ATTACHMENTS

The diaphragm presents; ...

- Vertebral attachment Dorsally
- Costal attachment Laterally
- Sternal attachment Ventrally

..... (See Figure 7 – 3)

OPENINGS

The diaphragm, while separating the thoracic and abdominal cavities, gives passage to a number of structures passing in both the directions.

Hiatus

An opening through diaphragm is known as “**hiatus**”. The diaphragm presents three chief openings;

TABLE 7 – 3: OPENINGS OF THE DIAPHRAGM

Name of Hiatus	Structures
Aortic hiatus	Aorta – Vena azygous – Cisterna chili
Esophageal hiatus	Esophagus - Vagus nerve
Caval hiatus	Caudal vena cava

RELATIONS (Major Structures)

Lungs – ribs – sternum – vertebrae – reticulum – liver – spleen – esophagus – large blood vessels i.e. aorta, caudal vena cava etc.

BLOOD SUPPLY

Two **phrenic arteries**, which are variable in origin; may come from aorta, celiac artery or intercostal artery, furnishes the diaphragm.

NERVE SUPPLY

The **phrenic nerve**, a motor nerve, innervates the crura of the diaphragm. It is formed by the union of the ventral branches of the fifth, sixth and seventh cervical nerves.

PLEU

The pleura is a thin serous membrane that lines the thorax.

DISTRIBUTION

With reference to its distribution, pleura has been subdivided into three parts;

1. Parietal Pleura

It is attached to the bony and muscular elements of the thorax by *endothoracic fascia*, a thin connective tissue layer. It is subdivided into three parts;

- a) **Vertebral pleura:** It lines the vertebral region inside the thoracic cavity.
- b) **Costal pleura:** It lines the thoracic wall that comprises ribs and intercostals spaces.
- c) **Sternal pleura:**The pleura that lines the sternum region.
- d) **Diaphragmatic pleura:** The pleura attached to the thoracic surface of the diaphragm.

2. Visceral Pleura

It is also named the *pulmonary pleura*.

It covers the surfaces and fissures of the lung, except at the hilus and along the attachment of the pulmonary ligament where it is continuous with the parietal pleura. It is firmly adherent to the lung and cannot be separated from it.

3. Mediastinal Pleura

It covers the blood vessels, the esophagus, the lymph nodes, etc. in the mediastinal space. It lines the corresponding surface of the mediastinum and named respectively as follows;

- a) **Cranial mediastinal pleura**
- b) **Middle mediastinal pleura**
- c) **Caudal mediastinal pleura**

PLICA VANAE CAVA

It is a distinct fold of pleura in which the caudal vena cava and phrenic nerve are enclosed.

LUNGS

The **lungs** are a pair of respiratory organs occupying major portion of the thoracic cavity and leave a little space for the heart.

CHARACTERISTICS

- They are accurately adapted to the walls of the cavity.
- The lungs are covered by *pulmonary pleura*.
- The right is almost twice as large as the left lung.
- Their consistency is more dense and leathery to the touch.
- They are duller in color and lobulation is distinct but lobes are small.

SHAPE AND WEIGHT

Each lung is conical, with the base resting on against the cranial side of the diaphragm and the apex in or close to the thoracic inlet. The adult lungs weigh about **350 grams to 1 kg**.

ATTACHMENTS

The lungs are free to move in pleural sacs but attached only by its **root** and by **pulmonary ligament**.

ROOT OF THE LUNG

It is formed by the structures which either enter or come out of the lung at the hilus.

Contents

The root of the lung is made up of the following structures:

1. Principal bronchus
2. One pulmonary artery
3. Varying number of pulmonary veins.

4. Bronchial arteries
5. Bronchial veins
6. Pulmonary plexus of nerves
7. Lymphatics of the lung
8. Bronchopulmonary lymph nodes
9. Areolar tissue

PULMONARY LIGAMENT

The parietal pleura surrounding the root of the lung extends downward beyond the root as a fold called the *pulmonary ligament*. The fold contains a thin layer loose areolar tissue with a few lymphatics.

MORPHOLOGY

Normal Lung	Foetal Lung
Normally pink in color	Pale grey in color
Soft, Spongy, Highly elastic	No such characteristics
Crepitates when pressed	Not crepitated
Floats in water	Sink in water

TABLE 7 – 4: COMPARISON ON MORPHOLOGY OF NORMAL AND FETAL LUNG.

DESCRIPTION

Each lung presents for description: apex (cranially), base (directed caudally) and;

Two Surfaces

- i) Medial or visceral
- ii) Costal

Three Borders

- i) Dorsal
- ii) Ventral
- iii) Basal

THE SURFACES

1. Costal Surface

It presents costal impressions principally.

..... (See Figure 7 – 4)

2. Visceral Surface

It presents hilus of the lung, grooves (for aorta, esophagus, vena azygous, anterior vena cava, posterior vena cava), impressions (of diaphragm, cardia), etc.

..... (See Figure 7 – 5)

BLOOD SUPPLY

The *pulmonary artery* carries venous blood to the lungs and returned to heart by pulmonary veins.

The nutritional arteries of lungs are *bronchial* and *esophageal branches* arise from the thoracic aorta.

Right Lung

The right lung presents four distinct lobes formed by interlobar fissure.

APICAL LOBE

It is as much larger as reach up to the left median plane.

It is partially subdivided into two parts_ **cranial** and **caudal**.

It is especially supplied with 3rd or **special bronchus** aroused by the trachea.

CARDIAC LOBE

It is elongated, three sided lobe which is separated from apical and diaphragmatic lobe by interlobar fissure.

DIAPHRAGMATIC LOBE

It is the largest lobe of the lung and positioned caudally.

ACCESSORY LOBE

It is pyramidal in shape and its apex is directed towards the hilus of the lung.

The left lung has no accessory lobe. The groove for posterior vena cava can be seen on the visceral surface by lifting this lobe upward.

Left Lung

The left lung is subdivided into two lobes by means of interlobar fissure.

APICAL LOBE

It is divided into two parts; viz.

- i. Cranially directed _ **apical part**.
- ii. Large three-sided ventrally directed _ **cardiac part**.

DIAPHRAGMATIC LOBE

It is the largest lobe of the lung which is positioned caudally.

.....
.....
.....

Chapter 8

BLOOD VASCULAR SYSTEM

Outline

- **Introduction to**
 - **Angiology**
 - **Blood vascular system**
 - **Division of Blood vessels**
 - **Portal System**
 - **Lymphatic system**
- **Pericardium**
- **Heart**
 - **Right atrium**
 - **Right ventricle**
 - **Left atrium**
 - **Left ventricle**
- **Introduction to Major Blood Vessels**
- **Systemic Arteries**
 - **Arteries cranial to heart**
 - **Branches of thoracic aorta**
 - **Branches of abdominal aorta**
 - **Arteries of the thoracic limb**
 - **Arteries of the pelvic limb**

ANGIOLOGY

Angiology is the description of the organs of circulation of the blood and lymph ---- the heart and the vessels.

BLOOD VASCULAR SYSTEM

It consists of;

1. Arteries:

Which convey blood from heart to the tissues.

2. Capillaries:

These are microscopic tubes in the tissue, which permit of the necessary interchange between the blood and the tissues.

3. Veins:

Which convey the blood back to the heart.

DIVISION OF BLOOD VESSELS

The blood vessels are divided into the pulmonary and the systemic.

PULMONARY ARTERY

The **pulmonary artery** conveys the blood from the right ventricle of the heart to the lungs, where it is arterialized, and is returned by the pulmonary veins to the left atrium of the heart.

SYSTEMIC ARTERIES

The **systemic arteries** convey the blood from the left ventricle all over the body, whence it is returned by the vena cavae (sing. vena cava) to the right atrium.

PORTAL SYSTEM

The term **portal system** is often applied to the portal vein and its tributaries which come from the stomach, intestine, pancreas and spleen.

The vein enters the liver, where it branches like an artery, so that the blood in this subsidiary system passes through a second set of capillaries (in the liver) before being conveyed to the heart by the hepatic veins and the posterior vena cava.

LYMPHATIC SYSTEM

The lymphatic system is subsidiary to the venous part of the circulatory system, from which it arises in embryo. It consists of the lymph vessels and glands.

LYMPH VESSELS

- These contain a colorless fluid, the lymph, in which are numerous lymphocytes.
- They resemble the veins in structure but have thinner walls and are provided with more numerous valves.
- The vessels have a characteristic beaded appearance when distended.
- Nearly all of the lymph is ultimately carried into the venous system by two trunks, the *thoracic duct* and the *right lymphatic duct*.

LYMPH GLANDS

- Also known as **Lymph nodes**.
- Lymph glands are intercalated in the course of the lymph vessels.
- They vary widely in size, some being microscopic, others several inches in length.
- In form they may be globular, ovoid and flattened, elongated or irregular.

UNIT OF LYMPH GLAND

The lymph nodule or follicle is the unit of structure of the lymph gland.

LYMPH NODULES

- Also known as **Lymph follicles**.
- They are minute masses of lymphoid tissue which occur in certain mucous membranes.
- They may be solitary, or aggregated into masses or patches.
- The lymph nodule is the unit of structure of the lymph gland.

PERICARDIUM

The **pericardium** (*Peri-* means “around”) is a fibro-serous sac which encloses the heart and the roots of the great vessels. It is situated in the middle mediastinum.

FORMATION

The pericardium is composed of two types of layers; viz.

Fibrous Layer

It is outermost, relatively thin, but strong and inelastic.

Serous Layer

It is a serous sac, surrounded by fibrous layer; it may be regarded as having two parts:

- PARIETAL PART:** It lines the fibrous layer, to which it is closely attached.
- VISCERAL PART:** It covers the heart, and parts of the great vessels.

Visceral part of serous pericardium is also termed as the *Epicardium*.

These two layers are continuous with each other at the roots of the great vessels i.e. ascending aorta, pulmonary trunk, vena cavae, and pulmonary veins.

PERICARDIAL SPACE

It is the space between the two serous layers of the pericardium. This space contains pericardial fluid called the *pericardial liquor*. Pericardial fluid prevents friction between the heart and the pericardium when the heart beats.

RELEVANT TERMS

EPICARDIUM: It is the visceral part of serous layer of pericardium that lines the heart muscles.

ENDOCARDIUM: .It lines the cavities of the heart i.e. atria and ventricles of the heart inside.

MYOCARDIUM:This term is applied peculiarly for the striped muscles of the heart.

PERICARDIAL LIQUOR:It is present in between the parietal and visceral layers.

HEART

The heart is a conical hollow muscular organ situated in the middle mediastinum. It is enclosed within the pericardium. It pumps blood to various parts of the body to meet their nutritive requirements.

NOMENCLATURE

The **Greek name** for the heart is *cardia* from which we have the adjective **cardia**.

The **Latin name** for the heart is *cor* from which we have the adjective **coronary**.

SURFACE MARKING

The heart is positioned from 2nd to 5th Rib, 2 inch above costo-chondral junction.

WEIGHT

The heart of a normal healthy animal (i.e. goat) weighs about **85 – 113 grams**.

DISCRIPTION

The heart presents; (See Figure 8 – 1)

Two Parts

i) Apex(faces ventrally, conical in appearance)

ii) Base (from where vessels originate)

Two Surfaces

i) Auricular(facing left thoracic wall)

ii) Atrial (facing right thoracic wall)

Two Borders

i) Cranial(convex and elongated)

ii) Caudal (Straight and short).

Four Chambers

i) Right atriumii) Right ventricleiii) Left atriumiv) Left ventricle

LIGAMENTS OF THE HEART

There are two ligaments of the heart;

i) Sterno-pericardial Ligament

This ligament attaches the apex of the heart with the sternum by the help of pericardium.

ii) Ligamentum Arteriosum

This ligament is present between the descending aorta and pulmonary artery.

BLOOD SUPPLY

The heart receives a large blood supply through the two *coronary arteries*, which arise by aorta.

The blood is returned by the *coronary veins* which open into the right atrium via coronary sinus.

OUTLOOK OF HEART

Heart outlook presents following structures;

Coronary Groove

Also called *atrioventricular groove*.

It is a circular groove indicated the division between atria and ventricle.

Coronary Fat

It lies on the coronary groove.

Longitudinal Grooves

Also termed the *interventricular grooves*.

It corresponds to the septum of the ventricles. There are two longitudinal grooves; viz.

- i) Right longitudinal groove
- ii) Left longitudinal groove.

CHAMBERS OF THE HEART

Right Atrium

The **right atrium** is the right upper chamber of the heart. It receives venous blood (deoxygenated blood) from the whole body; pump it to the right ventricle through the right atrioventricular or tricuspid opening.

PARTS

It consists of two parts;

- 1) **Sinus venorum:** It is a cavity into which all the venous blood is drained.
- 2) **Auricle:**It is a blind pouch or conical diverticulum that faces most cranially.

OPENINGS

There are five chief openings in case of right atrium; viz.

- i) Opening of Anterior vena cava.
- ii) Opening of Posterior vena cava.
- iii) Opening of Vena azygous
- iv) Coronary sinus (The venous blood of heart is drained through it.)
- v) Right atrio-ventricular orifice(opening).

GROSS FEATURES

PECTINATE MUSCLES: The whole cavity of auricle is crossed by transverse muscular ridges. The muscles are interconnected to form a reticular network.

CRISTA TERMINALIS: It is a crest formed by the termination of *pectinate* muscles.

CRISTA SUPRAVENTRICULARIS: It is plane, & smooth surface just above the atrio-ventricular orifice.

INTERVENOUS TUBERCLE: It is a ridge projects just in front of opening of posterior vena cava.

FOSSA OVALE: It is a diverticulum in septal wall; remnant of *foramen ovale* in fetus.

Right Ventricle

The right ventricle receives blood from the right atrium and pumps it to the lungs via. **pulmonary artery**. It forms cranial border of the heart but does not reach the apex.

OPENINGS

There are two openings in the right ventricle;

1. Right Atrio-ventricular Opening

It is a single opening for the blood to pass from right atrium to the right ventricle.

It is guarded by

TRICUSPID VALVE (MAINTAINS THE UNIDIRECTIONAL FLOW OF THE BLOOD)

It has three large cusps, **Semilunar Cusps**; attached to the **Papillary Muscles**, by mean of thread like structures called **Cordea Tendinea**.

2. Pulmonary Orifice(Opening)

It is guarded by

PULMONARY VALVE

GROSS FEATURES

CONUS ARTERIOSUM: It is a dome-shaped structure formed by right ventricle at the cranial border of the heart.

TRABECULAE CARNAE: It is the rough wall of ventricle which bears muscular ridges and bands.

MODERATE BANDS: These extend from septum to the opposite wall. The other name of Moderate band is “trabeculae septomarginalis”

Left Atrium

The left atrium receives oxygenated blood from the lungs through pulmonary veins, and pumps it to the left ventricle through the left atrioventricular or bicuspid or mitral orifice.

Note: In comparison to the Gross Features of both the atria, Anatomy parameters are quite similar.

OPENINGS

The left atrium has two types of openings:

1. Openings of Pulmonary Veins

About 6 -7 pulmonary veins get openings into the left atrium.

Through these openings, oxygenated blood is pour into this chamber.

2. Left Atrio-ventricular Orifice(Opening)

This opening is situated between the both chambers of the left part of the heart.

Left Ventricle

The left ventricle receives oxygenated blood from the left atrium and pumps it to the main blood vessel i.e. aorta. • It reaches up to the apex of the heart, therefore it is regularly conical than the right ventricle. • The wall of the left ventricle is much thicker as compared to that of the right ventricle.

OPENINGS

There are two openings in the left ventricle;

1. Left Atrio-ventricular Orifice

It is guarded by

BICUSPID VALVE (formerly called “Mitral valve”)

It has two broad, large, and thicker cusps, called **Semilunar Cusps**, attached to the **Papillary Muscles** by means of thread like structures known as **Cordae Tendinea**.

2. Aortic Orifice/Opening

It is guarded by.....

AORTIC VALVE:

It is composed of three semilunar cusps like that of pulmonary valve.

GROSS FEATURES

TRABECULAE CARNAE: The rough wall of ventricle which bears muscular ridges and bands.

MODERATE BANDS: These extend from septum to the opposite wall. They prevent overdistension.

VENTRICULAR SEPTUM: It is the partition which separates the cavities of the both ventricles.

INTRODUCTION TO MAJOR BLOOD VESSELS

AORTA

It is a large, unpaired vessel that emerges from left ventricle, medial to the pulmonary trunk. It starts at the base of the left ventricle.

ANTERIOR VENA CAVA

It returns the blood to the heart from the head, neck, thoracic limbs, and the greater part of the thoracic wall.

POSTERIOR VENA CAVA

It returns almost all of the blood from the abdomen, pelvis, and pelvic limbs. These vessels carry blood for/from the muscles of the heart.

THE OPENINGS OF BOTH VANA CAVA ARE VALVELESS.

SYSTEMIC ARTERIES

The systemic arteries convey the blood from left ventricle to all over the body.

DESCRIPTION

The systemic arteries may describe in the following ways; easier to understand.

1. Arteries cranial to the heart
2. Branches of Thoracic Aorta
3. Branches of Abdominal Aorta
4. Arteries of the Thoracic Limb
5. Major arteries of the Pelvic Limb

1. Arteries Cranial to Heart

..... (See Figure 8 – 2)

Name of Arteries	Origin	Tributaries	Area of Distribution
Coronary	Ascending aorta	Right and left coronary	Heart muscles
Brachiocephalic Trunk	Aortic arch	Bicarotid trunk, Right subclavian artery	----
Left Subclavian	Aortic arch	<ul style="list-style-type: none"> • Dorsal (costo-cervical) • Deep cervical • Vertebral • External thoracic • Inferior cervical • Axillary • Internal thoracic 	----
Right Subclavian	Brachiocephalic trunk	Same branches as that of left subclavian artery	----
Dorsal Cervical or Costo-cervical	Subclavian artery	Various branches	Intercostal muscles and Muscles of base of neck & dorsal thoracic vert.
Deep Cervical	Subclavian artery	Mediastinal branch	Base of neck & adjacent scapular region.
Vertebral	Subclavian	Muscular and spinal	Cervical muscles &

	artery	branches	spinal cord.
External Thoracic	Subclavian artery	-----	Pectoral muscles
Inferior Cervical	Subclavian artery	Ascending and descending branches	Muscles of neck and breast.
Axillary	Subclavian artery	-----	Muscles of thoracic limb
Internal Thoracic	Subclavian artery	-----	Muscles of sternum e.g. <i>transverses thoracic</i> etc

2. Branches of Thoracic Aorta

Name of Arteries	Origin	Area of Distribution
Bronchial	Thoracic aorta	Pulmonary tissues i.e. lung
Esophageal	Thoracic aorta	Esophagus
Intercostal • First 5 pairs • last 8 pairs	Thoracic aorta Dorsal cervical artery Thoracic aorta	Intercostals muscles
Phrenic	Variable in origin. May arise from aorta, coeliac or left ruminal Artery.	Crura of the diaphragm

3. Branches of Abdominal Aorta

Name of Arteries	Origin	Tributaries	Area of Distribution
COELIAC • Hepatic • Right Ruminal • Left Ruminal • Omaso-abomasal • Splenic	Abdominal aorta Celiac artery Celiac artery Celiac artery Celiac artery Celiac artery	---- ---- Pancreatic branch, dorsal & ventral coronary Reticular branch Dorsal and ventral branch ----	---- Hepatic tissues (liver) Both surfaces of the rumen Left face of the rumen Omasum and abomasum Spleen
Anterior Mesenteric	Abdominal aorta	----	Anterior part of small intestine
Renal (paired)	Abdominal aorta	----	Right & left kidneys
Spermatic (in male)	Abdominal aorta	----	Testis and epididymis
Uterovarian (in female)	Abdominal aorta	Uterine and ovarian branches	Ovaries, horn & body of

			uterus
Lumber (5-6 pairs)	Abdominal aorta	Dorsal and ventral branches	Interspinous & intertransverse spaces of lumbar vertebrae
Posterior Mesenteric	Abdominal aorta	----	Terminal part of rectum and colon
External Iliac (paired)	Abdominal aorta	Circumflex iliac A. - Continued as femoral artery	----
Internal Iliac (paired)	Abdominal aorta	Middle uterine and umbilical arteries	Perianal region
Middle Sacral	Abdominal aorta	Continued as middle coccygeal A.	Tail region & Coccygeus muscles.

4. Branches of the Thoracic Limb

Name of Arteries	Area of Distribution (Muscles and other structures)
Subscapular	Deep pectoral, Brachio-cephalicus (Muscles)
Subscapular • Thoraco-dorsal • Circumflex Arteries of Scapula • Posterior Circumflex Artery of humerus.	Subscapularis, Teres major, Triceps brachii (Muscles)
	Latissimus dorsi (Muscle)
	Supraspinatus, Infraspinatus, Teres minor (Muscles)
	Joint capsule, Muscles, and Skin of shoulder
Ant. Circumflex Artery of humerus	Deep pectoral, Coracobrachialis (Muscles)
Deep Brachial	Triceps brachii, Tensor fascia antibrachii (Muscles)
Muscular Branches	Teres major, Deep pectoral, Coracobrachialis, Biceps brachii
Ulnar	Muscles of lateral side of carpus
Nutrient Artery of humerus	Enters the nutrient foramen of humerus
Anterior Radial	Biceps brachii, Brachialis, Extensors M. of carpus and digits.
Median	<ul style="list-style-type: none"> • Direct continuation of brachial artery. • It ramifies/supplies the carpus, metacarpus region. • Also again gives off digital arteries.

5. Major Arteries of Pelvic Limb

Name of Arteries	Area of Distribution
FEMORAL It is the main arterial trunk of the thigh. It is the direct continuation of external iliac artery.	
Cranial Femoral It arises from the femoral artery.	Quadriceps femoris muscles

Caudal Femoral It arises from the femoral artery. Some times it may arise from the popliteal or medial circumflex femoral artery.	Biceps femoris, Vastus lateralis.
Saphenous It is a small vessel which arises from femoral at its middle.	Sartorius and gracilis muscles.
Popliteal It is direct continuation of femoral artery.	Gastrocnemius, superficial digital flexor
Cranial Tibial It is distal continuation of popliteal artery.	Cranial tibial, popliteus, soleus, proneus tertius, Lateral digital extensor.
Caudal Tibial It is smaller terminal branch of the popliteal artery.	Popliteal, superficial digital flexor, soleus, deep digital flexor.
Metatarsal It is the direct continuation of cranial tibial artery.	Metatarsus and digits.

.....
.....

Chapter 9

DIGESTIVE SYSTEM

Outline

Elements of Digestive System

- **Alimentary Canal**
 - **Mouth**
 - **Pharynx**
 - **Esophagus**
 - **Stomach**
 - **Small Intestine**
 - **Large intestine**
- **Accessory Organs**
 - **Tongue**
 - **Teeth**
 - **Salivary Glands**
 - **Liver**
 - **Pancreas**

Relevant Structures

- **Abdominal cavity**
 - **Peritoneum**
 - **Spleen**
-

The digestive system (**digestive tract**) consists of muscular tube lined with mucous membrane that is continuous with the external skin at the mouth and at the anus. Its primary functions are ingestion, mastication, digestion and absorption of food, and elimination of solid wastes.

ELEMENTS OF DIGESTIVE SYSTEM

The apparatus of the digestive system may comprise of two divisions:

1. **Alimentary Canal**
It is a tube that extends from the lips to the anus.
This canal consists of following consecutive segments;
Mouth, Pharynx, Esophagus, Stomach, Small intestine, and Large intestine
2. **Accessory Organs**
Tongue, Teeth, Salivary Glands, Liver, and Pancreas

OTHER RELEVANT STRUCTURES

Abdominal Cavity, Peritoneum, and Spleen

MOUTH

The mouth is the first part of alimentary canal and is used for holding, grinding, and mixing food with saliva but may also be used to manipulate the environment (through grasping of objects) and a defensive and offensive weapon.

PARTS

The mouth consists of two parts;

1. **VESTIBULE:**It is the small space between the teeth and lips.
2. **PROPER ORAL CAVITY:**Teeth and dental pad enclose this cavity.

It is occupied primarily by the tongue. It communicates to the pharynx through *isthmus faucium*.

Lips

These are two musculo-membranous folds which surround the orifice of the mouth. The upper lip of small ruminant including goat is deeply grooved with a midline, called *philtrum*.

The lips are densely innervated by sensory fibers, making them very sensitive tactile organs.

The lips of the sheep and goat are soft and flexible and aid in picking up food.

Cheeks

The cheeks form the sides of the mouth. These also present *conical papillae*.

Hard Palate

It is formed by horizontal elements of the incisive (premaxilla), maxilla, and palatine bones.

It is bounded in front and on sides by dental arches and is continuous with soft palate behind.

GROSS FEATURES (See Figure 9 – 1)

MEDIAN LINE/RAPHE: It divides the surface into two equal portions.

PALATINE RIDGES (15-19 in numbers): They cover about two third part of the hard palate.

INCISIVE PAPILLAE: It is present between the dental pad and first ridge of hard palate.

Soft Palate

It is a musculo-membranous curtain which separates the cavity of the mouth from that of pharynx.

Tonsils

The tonsils are *bean shaped* structures which are more or less circumscribed aggregation of lymphatic nodules reside in the *tonsilar sinus*. The tonsilar sinus is present on either side, behind the anterior pillars of the soft palate.

The **PALATINE TONSILS** lie in a pocket on the lateral wall of the pharynx ventral to the soft palate and adjacent to the base of the tongue. They do not project into the pharynx at all.

The **LINGUAL TONSILS** consist of accumulations of lymphatic nodules in the base of the tongue.

The **PHARYNGEAL TONSIL** is an accumulation of lymphoid tissue in the sub-mucosa of the dorsal pharyngeal wall.

TONGUE

The tongue consists of a mass of muscle covered by mucous membrane.

LOCATION

The tongue is situated on the floor of the mouth, between the rami of the mandible.

SHAPE AND COLOR

It is narrower in the middle of the body but width of the apex and root is almost same. The color is variable.

PARTS

The tongue is divided into three parts.

1. **ROOT:**It is attached to the hyoid bone, soft palate and pharynx.
2. **BODY:** It constitutes the main mass of the tongue.
3. **APEX:** It is free, pointed end of the tongue.

The entire tongue is mobile through its muscular attachments to the hyoid apparatus and mandible.

PAPILLARY ARRANGEMENT

The tongue is covered with keratinized stratified squamous epithelium. The surface is characterized by a large number of projections, the *papillae*, that are particularly well-developed on the dorsal surface.

..... (See Figure 9 – 2)

PAPILLA: It is an elevation on the tongue. These are of four kinds; viz.

- i. **Filliform** = thread-like
They are small thread like; soft to touch.
- ii. **Fungiform** = mushroom –like
They are relatively larger and scattered among filliform papillae.
- iii. **Lenticular:**
They are rounded papillae on dorsum linguae (dorsal prominence)
- iv. **Vallate** = cup-shaped
They are on each side of caudal part of prominence of dorsum.
They are almost 14-16 in number.

TASTE BUDS

Taste Buds are the organs of taste. Following three types of papillae are associated with these;

..... i) Fungiformii) Vallateiii) Foliate (absent in case of goat’s tongue).

GROSS FEATURES

DORSUM LINGUAE: It is a dorsal prominence on the dorsal surface of the tongue.

FRENULUM LINGAE: A fold of mucous membrane that is attached to the floor of the mouth.

TRANSVERSE GROOVE: A furrow present on the dorsal surface of the tongue transversely.

GLOSSO-EPIGLOTTIC FOLD: It passes from the root of the tongue to the base of the epiglottis.

TEETH

LOCATION

The teeth are implanted in the alveoli of the bones of the jaws. Teeth are arranged in two *dental arcades*, one associated with the mandible and one, with the incisive and maxillary bones.

PARTS

Basically, a tooth constitutes two parts;

- i) **CROWN:** It is the part of the tooth visible above the mucous membrane of the gum.
- ii) **ROOT:** A tooth is anchored by its root in a socket of a bone, called an alveolus.

COMPOSITION

Teeth are composed of four types of tissues; (from within to outward)

- i) **Pulp** : inner part of tooth that contains nerves, vessels, and loose connective tissue
- ii) **Dentine:** connective tissue surrounding the pulp
- iii) **Enamel** : outer surface located in the crown
- iv) **Cementum:** outer surface located in the root

DESCRIPTION

A tooth presents four surfaces;

1. **Vestibular:** The surface directed towards the lips (i.e. labial surface) and cheeks (i.e. buccal surface).
2. **Lingual:** The surface directed towards the tongue.
3. **Contact:** The surface in contact with adjacent tooth in the same dental pad.
4. **Masticating:** The surface which comes in contact with a tooth or teeth of oppo-site jaw.

SETS OF TEETH

All the domestic animals are *diphyodont*. This means they develop a set of deciduous teeth (also called baby teeth or milk teeth) that fall out and are replaced with permanent teeth.

Thus, there are two sets of teeth based on animals’ growth period.

- i) Deciduous Teeth
- ii) Permanent Teeth

TYPES OF TEETH

The teeth are of four types named as follows;

Incisor = front, cutting tooth.

Canine = long, pointed bonelike tooth for grasping and tearing.

Premolar = cheek tooth that grinds food.

Molar = caudal cheek tooth that grinds food.

DENTAL FORMULA

Dental formula represents the type and number of each tooth type found in that species.

Deciduous Teeth Formula	Permanent Teeth Formula
2 (Di 0/4 Dc 0/0 Dp 3/3) = 20	2 (I 0/4 C 0/0 Pm 3/3 M 3/3) = 32
Di = Incisors (of deciduous teeth) Dc = Canine of deciduous teeth Dp = Premolars (of deciduous teeth)	I = Incisors of permanent teeth C = Canines (of permanent teeth) Pm = Premolars of permanent teeth M = Molars (of permanent teeth)

SALIVARY GLANDS

SALIVA

The secretion of all the salivary glands is, collectively, called the **saliva**. It is the first secretion encountered by food in its progress through the alimentary tract.

The salivary glands empty their secretions through ducts that lead into various parts of the mouth at the gums. Saliva contains the starch-splitting amylase enzyme, **ptyalin**.

TYPES OF GLANDS

The salivary glands are basically, classified into two categories;

1. Chief Salivary Glands

- i) Parotid gland
- ii) Mandibular gland
- iii) Sublingual gland

2. Minor Salivary Gland

- i) Labial gland
- ii) Buccal gland
- iii) Lingual gland
- iv) Palatine gland

Parotid Gland

It is located ventral to the ear in relation to the caudal border of the mandible.

Mandibular Gland

It is usually located ventral to the parotid gland.

Sublingual Gland

It is located deep to the mucous membrane along the ventral side of the lateral surface of the tongue near the floor of the mouth.

NATURE OF SECRETIONS

The salivary glands are classified as serous, mucous or mixed. Serous glands secrete a watery fluid, as compared with mucous glands, which secrete mucus, a viscous material that acts as a protective covering for the surface of mucous membrane. A mixed gland produces both mucous and serous fluids.

The **parotid salivary gland** secretes primarily a serous saliva.

The **mandibular** and **sublingual glands** are classified as mixed glands.

Most of the **minor salivary glands** have a mucous secretion.

PHARYNX

The pharynx is a musculo-membranous sac which forms common passage for both the respiratory and digestive systems.

DIVISION

The pharynx is divided into three parts;

1. Oropharynx

Its dorsal and ventral boundaries are the soft palate and root of the tongue respectively.

2. Nasopharynx

It extends from the posterior nares to the junction of palatopharyngeal arches.

3. Laryngopharynx

It is situated dorsal to the larynx.

OPENINGS

The cavity of the pharynx presents seven openings as following:

- i) One opening ofOral cavity
- ii) Two openings of Nasal cavity
- iii) Two openings of Eustachian tubes
- iv) One opening ofLarynx (Aditus larynges)
- v) One opening ofEsophagus (Aditus oesophagi)

ESOPHAGUS

SYNONYM

The esophagus is also called *gullet*.

DEFINITION

The esophagus is a collapsible, musculo-membranous tube which extends from the pharynx to the stomach.

COURSE

From the pharynx, the esophagus passes dorsal to the trachea and usually inclines somewhat to the left in the neck in the mid-cervical region. It again passes dorsal to the trachea when it enters the thorax and continues caudally between the trachea and the aorta through the mediastinum to pass through the diaphragm at the esophageal hiatus.

Within the abdominal cavity, the esophagus joins the stomach.

DIVISION

The esophagus consists of two parts;

- i) Cervical Part
- ii) Thoracic part

BLOOD AND NERVE SUPPLY

The *esophageal artery*, from the thoracic aorta, furnishes the most of the part of esophagus. Esophageal muscles, both striated and smooth, are innervated by the *vagus nerve*.

STOMACH

SYNONYMS

The stomach is also called the *gaster* or *venter* from which we have the adjective *gastric* applied to structures related to the organ.

REPRESENTATIVE VALUES FOR ESOPHAGUS

DEFINITIONS

The stomach is the large dilatation of the alimentary canal just behind the diaphragm.

Total Length of the esophagus	45 cm
Diameter at the pharynx (where it starts)	1.8 cm
Diameter at cardia of stomach(when it ends)	2.5 cm

It is a muscular bag forming the widest and most distensible part of the digestive tube.

It intervenes between the esophagus and the small intestine.

Ruminants regurgitate and remasticate their food.

CHARACTERISTICS

It occupies nearly 3/4 of the abdominal cavity.

It covers almost all the left half of abdominal cavity except a small space.

The capacity of the stomach is about 15 to 18 liters (4 gallons).

COMPARTMENTS

The stomach of the ruminants e.g. Goat consists of four compartments; ... (See Figure 9 – 3)

- i) First Compartment..... **Rumen**
- ii) Second Compartment**Reticulum**
- iii) Third Compartment **Omasum**
- iv) Fourth Compartment**Abomasum**

FORESTOMACH

The first three compartments are collectively called forestomach.

The forestomach, called the *proventriculi* or *esophageal sacculation*, possesses a non-glandular mucous membrane; no secretions are produced.

TRUE STOMACH

The fourth compartment i.e. abomasum is the **true stomach**. It has a glandular mucous membrane, so only this compartment is responsible for gastric secretions.

ALL ABOUT RUMINANT STOMACH

Contribution of Rumen	71 %
Contribution of Reticulum	8 %
Contribution of Omasum	2 %
Contribution of Abomasum	19 %
As a whole Stomach of Goat	100 %

COMPARTMENTS OF STOMACH

RUMEN

Rumen = largest part that serves as a fermentation vat.

The rumen covers most of the left half of the abdominal cavity.

It extends considerably to the left of the median plane ventrally and caudally.

EXTERIOR VIEW

The rumen may be described as having.....

Two Surfaces

- i) Parietal surface
- ii) Visceral surface

Two Curvatures

- i) Dorsal curvature
- ii) Ventral curvature

Two Extremities

- i) Cranial extremity
- ii) Caudal extremity

GROSS FEATURES

The surface of the rumen is marked by the *right* and *left longitudinal grooves* which subdivide the rumen into dorsal and ventral sacs.

On posterior extremity, there are two blind sacs; *dorsal & ventral blind sacs*, separated by the *posterior transverse groove* and marked off from the remainder rumen by *dorsal* and *ventral coronary grooves*.

INTERIOR VIEW

Interiorly, the demarcation of grooves is replaced by the *pillars*.

Besides the pillars, all the surface area is being covered by *tongue-shaped papillae*; which give towel-like appearance.

ESOPHAGEAL GROOVE

It begins at the cardia of the stomach and ends at the reticulo-omasal orifice.

RETICULUM

Reticulum = most cranial portion

The reticulum is the most anterior part of the stomach. It lies mostly on the left of the median plane.

INTERIORLY

The folds presents 5 or 6 sided honey-comb like cells which also have serrated edges.

PATHOLOGICAL ASPECT

The location of the reticulum immediately caudal to the diaphragm places it opposite the heart, with only the muscular diaphragm between, so any foreign objects such as wire or nails that accumulate in the reticulum may be driven into pleural and pericardial spaces by the reticulum's muscular activity (**hardware disease**).

OMASUM

Omasum = third part that squeezes fluid out of the food bolus.

The omasum is the smallest compartment of the stomach. It lies chiefly to the right of median plane; ellipsoidal in form. The capacity of Omasum is about 300 ml.

LOCATION

It lies to the right of the ruminoreticulum, just caudal to the liver, and in the goat, normally is not in contact with the abdominal wall.

INTERIORLY

The omasum is filled with muscular laminae, called the *laminae omasi*.

These laminae look like the pages of a book, so omasum is also called the book stomach.

ABOMASUM

Abomasum = fourth part that is the true glandular stomach

The abomasum, true stomach, is an elongated sac which lies chiefly on the abdominal floor. The abomasum is the first glandular portion of the ruminant digestive system.

LOCATION

Its proximal portion is ventral to the omasum, and its body extends caudally on the right side of the rumen.

EXTERIORLY

The abomasum presents three main parts;

- i) **FUNDUS:** It is an anterior blind portion.
- ii) **BODY:** It is the central part.
- iii) **PYLORUS:** It joins the duodenum

INTERIORLY

The cavity of the abomasum is divided into three chief glandular regions;

- i) **Fundus Gland region:**It presents numerous spiral folds.
- ii) **Pyloric Gland region:** It is much narrower and small.
- iii) **Cardiac Gland region:** It is small confined area adjacent to omasabomasal orifice.

SMALL INTESTINE

The small intestine is the tube which connects the stomach with the large intestine.

ALL ABOUT SMALL INTESTINE

Total length of small intestine	25 meter
Average diameter of small intestine	2-3 cm

DIVISION

The small intestine is clearly divisible into two parts;

- i) **FIXED PART:** It is termed as the duodenum.
- ii) **MESENTERIC PART:** It consists of the jejunum and ileum.

PARTS

The small intestine consists of three parts as described below; (See Figure 9 – 4)

DUODENUM

The duodenum is the shortest, widest and most fixed part of the small intestine.

It is the first part of the small intestine, begins at the pylorus. It forms S-shaped curve distinctly.

It is about 2 to 3 feet (0.6 to 0.9 meters) long.

ATTACHMENT

It is closely attached to the right side of the dorsal body wall by a short mesentery, the *mesoduo-denum*.

OPENING

The bile duct and pancreatic duct joins together and opens at the same point in the duodenum, 25-40 cm away from the pylorus.

JEJUNUM

The jejunum is the longest part of the small intestine.

The jejunum is defined by the marked increase in the length of the supporting mesentery. It forms numerous coils arranged in festoon manner around the mesentery.

ATTACHMENT

The mesentery which attaches the jejunum named the *mesojejunum*.

ILEUM

The ileum is the short and last part of the small intestine that joins the great intestine.

It is distinguished from the jejunum by a fold of mesentery between it and the cecum.

Attachment

The portion of mesentery that is responsible for attachment of this small terminal part is called the *mesoillum*.

LARGE INTESTINE

The large intestine extends from the termination of the ileum to the anus.

ALL ABOUT CAECUM

Avg. length of Caecum	30 cm
Avg. Diameter of Caecum	8 cm
Avg. Capacity of Caecum	1- 1.5liter

PARTS

The large intestine, just like small intestine, is also divided into three parts; (See Figure 9 – 5)

CAECUM

The caecum is a cul-de sac between the small intestine and colon.
It presents three parts;

- i) Base
- ii) Body
- iii) Apex

COLON

The colon can be said to have;

Ascending colon → Proximal loop → spiral loop → Centripetal coils → Central flexure 
Descending colon ← Transverse colon ← Distal loop ← Centrifugal coils ← ← ← ← ← 

ATTACHMENT

This part of large intestine is attached with the lateral body wall by mean of a fold of peritoneum, called the **Mesocolon**.

3. RECTUM

The rectum is the terminal part of the alimentary canal. It extends from the pelvic inlet to the anus.

ATTACHMENT

The attachment of rectum is by mean of **Mesorectum**, a fold of peritoneum around rectum.

ABDOMINAL CAVITY

The abdominal cavity is the largest of the body cavities.
It encloses the peritoneal cavity between its parietal and visceral layers.
It is separated from the thoracic cavity by..... Diaphragm.
It is continuous behind with Pelvic cavity.

FLANK

It is the part of the lateral wall of the abdominal cavity which is formed only of soft organs.

PARALUMBER FOSSA

It is the triangular depression on the upper part of the flank.

PERITONEUM

INTRODUCTION

The peritoneum is a large thin serous membrane which lines the abdominal cavity and pelvic cavity. It is in the form of a closed sac which is invaginated by a number of viscera.

PERITONEAL CAVITY

The peritoneal cavity is the cavity formed by the lining of the peritoneum.

COMPOSITION

The peritoneum is composed of an outer layer of fibrous tissue, which gives strength to the mem-brane and an inner layer of meso-thelial cells which secrete a serous fluid which lubricates the surface, thus allowing free movements of viscera.

LAYERS OF PERITONEUM

As a result, the peritoneum is divided into:

- (i) An outer or parietal layer
- (ii) An inner or visceral layer
- (iii) Folds of peritoneum by which the viscera are

suspended.

Parietal Peritoneum

It lines the inner surface of the abdominal and pelvic walls and the lower surface of the diaphragm. It is loosely attached to the walls by **extraperitoneal** connective tissue and can, therefore, be easily stripped.

Visceral Peritoneum

It lines the outer surface of the viscera, to which it is firmly adherent and can not be stripped. In fact, it forms a part and parcel of the viscera.

Folds of Peritoneum

Many organs within the abdomen are suspended by folds of peritoneum. Such organs are mobile. The degree and direction of mobility are governed by the size and direction of the peritoneal fold. Other organs are fixed and immobile. They rest directly on the dorsal abdominal wall. These organs are said to be *retroperitoneal*.

Peritoneal folds are given various names;

(i) Large peritoneal folds attached to the stomach are called *omenta* singular of which is *omentum* which means "cover".

OMENTUM

It is a fold of peritoneum which passes from the stomach to other viscera.

TYPES OF OMENTA

- i) **GREATER OMENTUM:** It extends from greater curvature of stomach like an apron.
- ii) **LESSER OMENTUM:** It extends from lesser curvature of the stomach.
- iii) **GASTRO-SPLENIC OMENTUM:** ...It extends from the greater curvature to the spleen.

(ii) In general, the name of the fold is made up of the prefix "*mes*" or "*meso*" followed by the name of the organ. For example, the fold suspending the small intestine or *enteron* is called the mesentery; and a fold suspending part of the colon is called mesocolon.

MESENTARY

It is a fold of peritoneum which attaches the intestines to the dorsal wall of the abdomen.

TYPES OF MESENTARY

- Mesoduodnum, Mesojejunum and Mesoilium**..... Attach the small intestine.
- Mesocolon & Mesorectum** Attach the large intestine.

(iii) In many situations, double-layered folds of peritoneum connect organs to the abdominal wall or each other. Such folds are called **LIGAMENTS**.

FUNCTIONS OF PERITONEUM

1. **MOVEMENTS OF VISCERA:** The chief function of the peritoneum is to provide a slippery surface for free movements of abdominal viscera. They permits peristaltic movements of the stomach and intestines.
2. **PROTECTION OF VISCERA:** The peritoneum contains various phagocytic cells which guard against infection. Lymphocytes present in normal peritoneal fluid provide both cellular and humoral immunological defense mechanisms.
3. **ABSORPTION:** The mesothelium acts as a semipermeable membrane across which fluids and small molecules of various solutes can pass. Thus, the peritoneum can absorb fluid effusions from the peritoneal cavity.
4. **HEALING POWER AND ADHESION:** The mesothelial cells of the peritoneum can transfer into fibro-blasts which promote healing of the wounds. They may also form abnormal adhesions causing obstruction in hollow organs.
5. **STORAGE OF FAT:** Peritoneal folds are capable of storing large amounts of fats; particularly in obese individuals.

LIVER

SYNONYM

The liver is also called the "*hepar*" from which we have the adjective '*hepatic*' applied to many structures connected to this organ.

DEFINITION

The liver is the largest gland of the body, constituting about 1-2 % of total adult body weight. It secretes bile and performs various other metabolic functions.

COLOR AND WEIGHT

The liver is red-brown in color and quite friable. The weight of the liver is about **550 to 700 grams**.

LOCATION

The liver is always located immediately caudal to the diaphragm (in contact with it) and tends to be located on the right side as the reticulo-rumen pushes everything else to the right.

DESCRIPTION

The liver presents two surfaces;

(i) Parietal Surface

It is attached with the diaphragm and with last 2-3 rib.

(ii) Visceral Surface

It is related to the reticulum, omasum, and abomasum, pancreas and esophagus.

The caudate process possesses a deep depression for right kidney.

PARIETAL SURFACE

The parietal surface is also known as *diaphragmatic surface*.

It is convex and is related to the most part of the diaphragm.

IMPRESSIONS

A small part of parietal surface is in contact with the last 2-3 ribs and presents costal impression.

VISCERAL SURFACE

The visceral surface of the liver presents following features; (See Figure 9 – 5)

1. Portal Fissure:

It is well-defined rounded depression, which contains portal vein, hepatic duct hepatic artery and several hepatic lymph glands.

2. Umbilical fissure:

It is deep & partially divides gland into two chief lobes; dorsal & ventral.

IMPRESSIONS

The Organs which are in contact with the liver gives impressions.

More prominent impressions are.....

i) Reticular impression

ii) Omasal impression

iii) Abomasal impression

iv) Renal impression (possess by the right

kidney)

3. Esophageal Notch:

It is represented by a slight impression.

4. Fossa Vena Cava:

When the vessel of posterior vena cava is removed, underlie deep depression is known as fossa vena cava.

Gall Bladder

It is pear-shaped sac that lies partially in contact with the visceral surface of the liver.

It is regarded as the diverticulum of the bile duct; or reservoir for the bile.

CYSTIC DUCT: The neck of the gall bladder is continued by a small duct, called cystic duct.

COMMON BILE DUCT

It is the tube that carries bile and opens into the duodenum 25-40 cm away from pylorus.

Formation

The bile leaves the liver through hepatic ducts, which join the cystic duct from the gallbladder to form the common bile duct.

Cystic duct + Hepatic duct = Common Bile duct

LIGAMENTS OF THE LIVER

The attachment of the liver is governed by six chief ligaments;

1. Coronary Ligament
2. Falciform Ligament
3. Hepatorenal Ligament kidney
4. Round Ligament
5. Right Lateral Ligament
6. Left Lateral Ligament

BLOOD SUPPLY

The liver receives two blood supplies.

1. The **Hepatic artery**, a branch of **coeliac artery** (first branch of abdominal aorta) supplies the liver. It is the nutrient blood artery of liver.
2. The **Portal vein** carries blood from the stomach, intestines and spleen to the liver, while all the venous blood is pour down into the posterior vena cava via hepatic veins.

FUNCTIONS OF LIVER

1. **METABOLISM** of carbohydrates, fats and proteins.
2. **SYNTHESIS** of bile and prothrombin.
3. **EXCRETION** of drugs, toxins, poisons, cholesterol, bile pigments and heavy metals
4. **PROTECTIVE** by conjugation, destruction, phagocytosis, antibody formation and excretion.
5. **STORAGE** of glycogen, iron, fat, vitamin A and D.

SPLEEN

INTRODUCTION

The spleen is, normally called the graveyard of RBCs (Red blood cells).

The spleen is a lymphatic organ which acts as a filter for blood and plays an important role in the immune responses of the body. It is approximately triangular in outline; with the angles round off.

ALL ABOUT SPLEEN

Weight of the spleen	Aprox. 100 grams
Length of the spleen	12 -15 cm
Greatest width of spleen	7.5 -10 cm

SHAPE AND WEIGHT

The spleen is oyster shaped, soft or elastic to the touch and weighs about 56-85 grams.

LOCATION

It lies on the dorsal sac of the rumen just behind the diaphragm.

DESCRIPTION

The spleen may be described as having;

Two Ends

- i) Dorsal end or base
- ii) Ventral end

Two Surfaces

- i) Parietal surface
- ii) Visceral surface

Two Borders

- i) Anterior border
- ii) Posterior border

PARIETAL SURFACE

It is convex and is related to the diaphragm.

It often shows impressions of last three ribs; *costal impressions*.

VISCERAL SURFACE

It is concave and its anterior half is attached to the greater curvature of the rumen.

The visceral surface presents following features;

- i) **HILUS**: It is present close to the antero-basal angle.
- ii) **LINE OF PERITONEAL REFLECTION**

LIGAMENTS

There are two ligaments that attach the spleen with other viscera.

- 1. **Gastro-splenic Omentum**

It extends from the visceral surface of the spleen to the greater curvature of the rumen.

- 2. **Suspensory Ligament**

BLOOD SUPPLY

The *splenic artery*; a branch of the celiac artery enters the hilus of the spleen.

The *splenic vein* carries blood to the portal vein.

FUNCTIONS OF SPLEEN

- 1. **PHAGOCYTOSIS**: The spleen is an important component of the reticulo-endothelial system.
- 2. **HAEMOPOIESIS**: It is an important haemopoietic organ during foetal life but lymphopoiesis continues throughout life.
- 3. **IMMUNE RESPONSES**: Under antigenic stimulation, there occurs increased lymphopoiesis for cellular responses and increased formation of plasma cells for the humoral responses.
- 4. **STORAGE OF RBCs**: Red blood cells can be stored in the spleen and released into the circulation when needed.

PANCREAS

The pancreas (*pan* = all; *kreas* = flesh) is a gland that is partly exocrine and partly endocrine. The exocrine part secretes the digestive pancreatic juice and the endocrine part secretes hormones, e.g. insulin. It is soft, reddish brown, loosely lobulated and elongated organ.

SHAPE AND WEIGHT

Roughly the pancreas' shape is like an oak leaf.

The weight of the pancreas is about 50 to 70 grams.

LOCATION

The pancreas lies entirely to the right of the median plane.

It mostly lies on the visceral surface of the liver and attached with the duodenum.

It is deeply notched to the liver to accommodate the portal vein.

LOBES OF PANCREAS

There are two lobes of the pancreas; (See Figure 9 – 6)

- i) A large Right Lobe
- ii) A small Left Lobe.

BLOOD SUPPLY

The arteries of the pancreas, *pancreatic arteries*, come from the branches of the celiac & anterior mesenteric arteries. The *pancreatic veins* carry blood to the portal vein.

FUNCTIONS OF PANCREAS

- 1. **DIGESTIVE**: Pancreatic juice contains many digestive enzymes of which the important ones are as follows; Trypsin Amylase Lipase.
- 2. **ENDOCRINE**: Insulin helps in utilizations of sugar in the cells. Deficiency of insulin results in hyper-glycemia. The disease is called *diabetes mellitus*.
- 3. **PANCREATIC JUICE**: It provides appropriate alkaline medium (pH – 8) for the activity of the pancreatic enzymes.

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Chapter 10

URINARY SYSTEM

Outline

- **Essentials of Urinary System**
 - Kidneys
 - Structure of nephron
 - Ureters
 - Urinary bladder
 - Urethra
 - Male urethra
 - Female urethra
-

Urinary system removes wastes from the body. The urinary system also maintains homeostasis or a constant internal environment within the body

ESSENTIALS OF URINARY SYSTEM

The urinary system consists of two kidneys, two ureters, the urinary bladder and the urethra.

KIDNEYS

SYNONYMS

The kidneys are also called *renes* from which we have the derivative *renal*; and *nephros* from which we have the terms *nephron*, *nephritis*, etc.

INTRODUCTION

The kidneys are a pair of excretory organs situated in the dorsal part of the abdominal cavity on each side of the aorta and caudal vena cava, just ventral to the first few lumbar vertebrae. They lie behind the peritoneum. They remove the waste products of metabolism and excess of water and salts from the blood, and maintains its pH.

LOCATION

The kidneys usually lie ventral to the first three lumbar transverse processes; against the dorsal wall of the abdominal cavity. The kidneys are described as *retroperitoneal*, reflecting their location outside the peritoneal cavity, where they are more closely attached to the abdominal wall by fascia, vessels, and peritoneum than are most other abdominal organs.

RELATIVE POSITION

The right kidney is slightly more cranial than the left. The left kidney tends to be more pendulous, and the forestomach may push the left kidney to the right as far as the median plane or beyond, particularly when the rumen is full.

MORPHOLOGY

The kidneys are bean-shaped and smooth, without any lobulation. They are elliptical in form.

Structure of Nephron

The structures of a nephron include:

GLOMERULUS = cluster of capillaries

BOWMAN'S CAPSULE = cup-shaped structure that contains the glomerulus

PROXIMAL CONVOLUTED TUBULES = hollow tubes involved in reabsorption

LOOP OF HENLE = U-shaped turn that is involved in reabsorption

DISTAL CONVOLUTED TUBULES = hollow tubes involved in secretion

COLLECTING TUBULES = hollow tubes that carry urine from the cortex to the renal pelvis

DESCRIPTION

Each kidney presents:

Two Surfaces

- i. Dorsal surface
- ii. ventral surface

TWO BORDERS

- i. Medial border
- ii. Lateral border

TWO EXTREMITIES

- i. Anterior extremity
- ii. Posterior extremity

..... (See Figure 10 – 1)

GROSS FEATURES OF A KIDNEY

Naked eye examination of a coronal section of the kidney shows two distinguishable zones and other structures;

Cortex: It is the peripheral part of the renal parenchyma.

It contains the renal corpuscles and convoluted portion of the tubules.

Medulla: It is centrally located dense parenchyma of the kidney.

It gives striated appearance due to presence of numerous collecting ducts in this region.

Cortico-medullary Junction: is formed by the joining part of the cortex and medulla.

Renal capsule: is the outermost strong fibrous covering of the kidney.

Hilus: is present in the middle of the medial border. It passes through the artery, veins and ureters.

Renal Pelvis: is the expanded portion of the ureter within the kidney.

Renal Sinus: is the fat-filled space that contains the vessels and surrounds renal pelvis.

Renal Pyramid: is formed by the medulla portion of the kidney; It is also triangular in outline.

Renal Papilla: is the blunt tip of the renal pyramid which opens into the renal pelvis.

Renal Crest: is formed by the fusion of 12-16 papillae of renal pyramids. Other name; "common papillae"

Arcuate branches: of the renal vessels are apparent at the cortico-medullary junction.

■ **Structural anatomy of both the kidneys is almost similar.**

..... (See Figure 10 – 2)

FIXATION OF KIDNEYS

The kidneys are held in position chiefly by:

- (i) The pressure of adjacent organs
- (ii) The perirenal fat (*capsule adiposa*)

BLOOD SUPPLY

Because of its important role in adjusting the composition of extracellular fluid (including plasma), the blood supply to the kidney is much more extensive than the size of the organ would suggest. The two **renal arteries** may receive as much as one fourth of the total cardiac output.

Each renal artery enters the hilus of the kidney and divides into a number of relatively large branches, the **interlobar arteries**. These pass peripherally between pyramids almost to cortex, where they bend abruptly and become **arcuate arteries**, which derived their name from the arched manner by which they pass along the junction between cortex and medulla.

The **arcuate veins** drain blood from both the cortex and medulla, pass through the medulla as interlobar veins, and enter the renal veins, which emerge from the renal hilus to empty into the caudal vena cava.

NERVE SUPPLY

Sympathetic nerves are the primary innervation of the kidneys. These derive from the celiacomesenteric plexus and innervate blood vessels and renal tubules.

DIFFERENTIAL FEATURES BETWEEN RIGHT AND LEFT KIDNEYS

RIGHT KIDNEY	LEFT KIDNEY
It is usually a little further cranial.	It is more cauded than the right kidney.
It is quite fixed in position/immovable	It shows slight movement which is caused by the filling of the rumen. / movable
It is extensively related to liver than any other organ.	Its cranial extremity is related to the spleen and dorsal sac of the rumen.
It is related ventrally to the duodenum, right lobe of pancreas, the caecum and descending colon.	It is ventrally related to the descending colon, and the small intestine.
The medial border is related to caudal vena cava.	The medial border is close to the abdominal aorta.

URETERS

The **ureters** are a pair of narrow, thick walled muscular tubes which convey urine from the kidneys to the urinary bladder. The ureter begins at the renal pelvis and terminates at the urinary bladder.

There are two ureters; one for each kidney, named as right and left ureters.

STRUCTURE

The smooth muscle of the ureter undergoes peristaltic waves of contraction that encourage the flow of urine to the urinary bladder.

DIVISIONS

A ureter may be dividable into two parts;

- (i) Abdominal part of ureter
- (ii) Pelvic part of ureter

URINARY BLADDER

The urinary bladder is the temporary store house and muscular reservoir of urine which gets emptied through the urethra. The *detrusor muscle* of urinary bladder is arranged in whorls and spirals and is adapted for mass contraction rather than peristalsis.

SHAPE

The urinary bladder is a long, narrow pisiform mass.

PARTS

It may present three main parts;

- (i) **Vertex:** It is the anterior blind part.
- (ii) **Body:** It is the middle rounded part of the bladder.
- (iii) **Neck :** It is the posterior narrower extremity that joins the urethra.

LIGAMENTS

The urinary bladder is fixed in position by the two types of ligaments.

- (i) Lateral ligament; two in numbers
- (ii) Medial ligaments

URETHRA

The urethra is the long mucus tube which extends from the bladder to the glans penis.
The urethra is a tube extending from the urinary bladder to the outside of the body.

MALE URETHRA

The male urethra subserving the functions of urination and ejaculation i.e. expulsion of semen

FEMALE URETHRA

The female urethra is for urination only.

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Chapter 11

MALE REPRODUCTIVE SYSTEM

Outline

- **Essentials of Male Reproductive System**
 - Two testicles
 - Epididymis
 - Ductus deferens
 - Accessory sex glands
 - Seminal vesicles
 - Prostate gland
 - Bulbo-urethral
 - Penis
 - Muscles of penis
 - Prepuce
 - Urethra
- **Other Relevant structures**
 - Scrotum
 - Spermatic cord
 - Inguinal canal
 - Descent of the testis
 - Castration

The organs and glands of the male reproductive tract manufacture the male gamete (*spermatozoon* or sperm) and deliver it to the female reproductive tract.

ESSENTIALS OF MALE REPRODUCTIVE SYSTEM

The male reproductive system consists of two testes (testicles), ductus deferens, accessory sex glands, the urethra and the penis.(See Figure 11 – 1 & Figure 11 – 4)

SCROTUM

The scrotum is a cutaneous sac that conforms in size and shape to the testes it contains. It is the diverticulum of the abdomen in which the testes rest. It is ovoid, compressed cranio-caudally, long and pendulous.

LAYERS

The scrotum consists of four layers. (outward to inward)

- i) Skin: It is thin, elastic and hairy.
- ii) Tunica dartos: It is reddish in color and closely adherent to skin.
- iii) Scrotal fascia
- iv) Parietal layer of Tunica vaginalis.

CONTENTS

The scrotum contains the following structures:

1. Right and left testes.
2. the epididymis
3. lower parts of spermatic cord

TESTES

The testes (testicles) are the male gonads. They are homologous with the ovary of the female. The spermatic cord (discussed below) suspends each individual testis within the scrotum.

SITUATION

The testicles are held near to the sigmoid (S-shaped) flexure of the penis.

DIMENSION

Each testis weighs about 250-300 gm and its length is about 10 cm.

Each testis is elongated and oval in outline and its long axis is nearly vertical.

DESCRIPTION

Each testis presents for its description;

Two Surfaces

- i) Medial surface
- ii) Lateral surface

Both the surfaces are smooth & convex.

Two Borders

- i) Free border: It is cranial in position.
- ii) Attached or Epididymal border: It is caudal in position.

Two Extremities

- i) Anterior extremity (head)
 - ii) Posterior extremity (tail)
- Both extremities are rounded.

STRUCTURE

Each testis consists of a mass of coiled *seminiferous tubules* surrounded by a heavy fibrous capsule called the tunica albuginea. A number of fibrous septa, also called *trabeculae*, pass inward from the tunica albuginea, dividing the testis into lobules and providing a framework for support of the seminiferous tubules and the interstitial tissue that produces testosterone. The seminiferous tubules are the site of *spermatogenesis*, the formation of spermatozoa.

The connective tissue between the seminiferous tubules contains the *interstitial cells* (Leydig cells). The interstitial cells secrete the male hormone testosterone when stimulated by the pituitary gonadotropin LH.

Sustentacular cells (Sertoli cells) within the seminiferous tubules envelop developing spermatozoa and their precursors. These cells nourish the developing sperms.

Epididymis

The epididymis is the tube at the upper part of each testis that secretes part of the semen, stores semen before ejaculation, and provides a passageway for sperms. It is closely attached to the caudal border of the testicle..... (See Figure 11 – 2)

The epididymis is composed of a long, convoluted tube that connects the efferent ductules of the testis with the ductus deferens.

PARTS OF EPIDIDYMIS

The epididymis is arbitrarily divided into three parts;

- i) Head: into which the efferent ductules empty.
- ii) Body: Lying on the long axis of the testis.
- iii) Tail: that is attached by ligaments directly to the testis and to the adjacent tunica vaginalis.

LIGAMENTS OF THE TESTIS AND EPIDIDYMIS

There are two ligaments in this aspect, viz;

- a) Ligament of the testis.
- b) Ligament of the tail of the epididymis.

DUCTUS DEFERENS

The ductus deferens, commonly termed the vas deferens. (See Figure 11 – 2)
The ductus deferens is a muscular tube that undergoes peristaltic contraction during ejaculation, propelling the spermatozoa from the epididymis to the urethra. It extends from the tail of the epididymis to the pelvic part of the urethra.
The tail of the epididymis is continued as ductus deferens. The ductus deferens leaves the tail of the epididymis, passes through the inguinal canal as a part of the spermatic cord.

SPERMATIC CORD

The spermatic cord begins at the deep inguinal ring, where its constituent parts come together, extends obliquely downward through inguinal canal.

CONSTITUENTS OF SPERMATIC CORD

The spermatic cord consists of the following seven structures.

- 1) Spermatic artery
- 2) Spermatic veins
- 3) Lymphatics
- 4) Sympathetic nerves
- 5) Ductus deferens
- 6) Internal cremaster muscle
- 7) Visceral layer of tunica vaginalis

The first four constituents of spermatic cord are gathered into a rounded mass by mean of connective tissue.

TUNICA VAGINALIS

It is a fold of peritoneum which extends from the inguinal canal to bottom of the scrotum. It consists of two layers.

- 1) Parietal layer of Tunica vaginalis: It lines the scrotum below.
- 2) Visceral layer of Tunica vaginalis:It covers spermatic cord, testicle and epididymis.

TUNICA ALBOGINEA

It is a strong capsule composed of dense white fibrous tissue & unstriped muscle fibers.

INGUINAL CANAL

The inguinal canal is a passage from the abdominal cavity to the exterior of the body that extends from the deep inguinal ring to the superficial inguinal ring. The deep (internal) inguinal ring is a space or potential space between the caudal border of the internal abdominal oblique muscle and the deep face of the aponeurosis (flat tendon) of the external abdominal oblique muscle.

The superficial inguinal ring is merely a slit in the aponeurosis of the external abdominal oblique muscle.

In addition to the spermatic cord, the canal allows passage of the external pudendal artery and a sensory nerve that serves the inguinal region of the abdominal wall.

DESCENT OF THE TESTES

In both male and female fetuses, the gonads develop in the sublumbar region immediately caudal to the kidneys. In the female animal, the ovaries remain in the abdominal cavity near their origin; but in the male animal, the testes travel (descend) a considerable distance from their point of origin to the scrotum.

The environment of the scrotum features a temperature a few degree lower than that of the normal body temperature; this lowers temperature is favorable to spermatogenesis.

The descent of the testis normally is complete by birth or soon after. It is guided on its journey by the fibrous gubernaculum, a cord like structure that initially extends from the testis through the inguinal canal to the skin in the region that will become the scrotum. As the fetus grows, the gubernaculum draws the testis from the abdominal cavity into the scrotum.

CRYPTORCHISM

It is the condition which is characterized by the indefinite retention of one testicle or both in the abdominal cavity.

CASTRATION

Castration is a term usually applied to removal of the testis of the male animal, although technically it can apply to ovariectomy (removal of the ovaries) of the female animal as well. Early castration also improves the quality of meat animal by inhibiting undesirable secondary sex characteristics (notably the failure to develop marbling of muscle). Table 24-1 lists the common terms for intact and castrated male animals.

Species	Intact Adult Male	Castrated Male
Horse	Stallion	Gelding
Ox	Bull	Steer
Pig	Boar	Barrow
Sheep	Ram	Wether
Goat	Buck	Wether
Chicken	Rooster	Capon

MALE ACCESSORY SEX GLANDS

The male accessory sex glands produce the bulk of the ejaculate, or semen, the medium for transport of sperm. Semen provides favorable conditions for nutrition of sperm and act as a buffer against the natural acidity of the female genital tract.

The accessory sex glands include the seminal vesicles, the prostate gland and the bulbourethral glands.

Male Accessory Sex Glands

Species	Prostate	Seminal Vesicles	Bulbourethral
Horse	+	+	+
Ruminants	+	+	+
Pig	+	+	+
Dog	+	-	-
Cat	+	-	+

+ = Present, - = Absent

Prostate Gland

The **prostate gland** is an unpaired gland that more or less completely surrounds the pelvic urethra.

The prostate gland comprises various combinations of diffuse and compact parts extending along the pelvic urethra under cover of the urethral muscle. The prostate produces an alkaline secretion that gives semen its characteristic odor. In older intact male animals, the prostate may become enlarged and interfere with urination.

Seminal Vesicles

The **seminal vesicles** (formerly called *vesicular glands*) are paired glands associated with the genital fold. They are lobulated glands of considerable size. Each vesicular gland merges with the ipsilateral ductus deferens, creating the short ejaculatory duct, which empties in to the pelvic urethra.

Bulbourethral Glands

The Bulbourethral (formerly Cowper's) glands are paired glands on either side of the pelvic urethra just cranial to the ischial arch but caudal to the other accessory glands.

PENIS

The penis is the male organ of copulation which is composed essentially of erectile tissue. It is long, cylindrical with a very much smaller in diameter.

SIGMOID FLEXURE

Just behind the scrotum, it forms an S-shaped curve, called Sigmoid flexure. The position of the flexure affected during erection.

PARTS

The penis presents three main parts:

a. Root of the penis:

It is attached to the lateral parts of the ischial tuberosity.

b. Body:

It constitutes the bulk of the organ.

c. Glans penis:

It is the terminal part and free end of the organ.

GROSS FEATURES (See Figure 11 – 3)

EXTERNAL URETHRAL ORIFICE: It is small external opening of the urethra.

URETHRAL PROCESS: It is a projection twisted in appearance just beyond the glans penis.

GALAE GLANDIS: It is the most anterior part of the glans penis.

CORONA GLANDIS: The galae glandis is surrounded by a prominent margin called corona glandis.

COLLUM GLANDIS: It is the constricted part behind the corona glandis.

RAPHE GLANDIS: It is a furrow/line at the glans penis region.

MUSCLES OF THE PENIS (**See Figure 11 – 5**)

1) Ischio-cavernosum

It is short but strong paired muscle which attaches the root of the penis to the ischial arch.

ACTION: It pulls the penis against the pelvis.

2) Corpus cavernosum penis

It forms the greater part of the bulk of the penis.

3) Corpus cavernosum urethra

Corpus cavernosum urethra M. is also termed *corpus spongiosum*.

It forms a tube around the urethra.

In a cross-section, it may look like dots due to its longitudinal arrangement.

4) Bulbo-cavernosus

This muscle is present in a circular fashion around the proceeding muscle in a cross sectional view.

5) Retractor penis

This muscle comprises of two strips which is the continuation of the suspensory ligament.

ACTION: To withdraw the penis into the sheath/prepuce after erection.

PREPUCE

The prepuce is an invaginated fold of skin surrounding the free extremity of the penis. The outer surface is fairly typical skin, while the inner mucous membrane consists of a preputial layer lining the prepuce and a penile layer covering the surface of the free extremity of the penis.

PARTS

It presents two main parts; External and Internal.

MALE URETHRA

The male urethra is a long mucous tube which extends from the urinary bladder to the glans penis.

LOCATION

The urethra lies in a groove on the ventral surface of the corpus cavernosum penis muscle.

COURSE

It passes caudally on the floor of the pelvis, turns around the ischial arch, forming a sharp bend, and passes forward as a part of the penis, enclosed in the corpus cavernosum urethrae.

PARTS

It may be divided into two parts;

- i) Pelvic part
- ii) Extrapelvic part

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Chapter 12

FEMALE REPRODUCTIVE SYSTEM

Outline

- **Components of female genital tract**
 - Ovaries
 - Uterine tubes
 - Uterus
 - Horns
 - Body
 - Cervix
 - Vagina
 - Vulva
 - Clitoris
 - Female Urethra
- **Ligaments of female genital organs**
- **Mammary glands**

The female reproductive tract produces female gamete (ovum, pl. ova), delivers it to a site where it can be fertilized by the male gamete (sperm), provides an environment for the development and growth of the embryo, and expels the fetus when it is capable of survival outside of the mother's body.

COMPONENTS OF FEMALE REPRODUCTIVE SYSTEM

The female organs of reproduction include: two Ovaries, two uterine tubes (fallopian tubes or oviducts), the uterus, the vagina, the vulva. (See Figure 12 – 2)

OVARIES

The **ovaries**, like the testes in the male, are the primary organs of reproduction in the female. The ovaries are both endocrine and cytogenic (cell-producing), since they produce hormones, which are released directly into the blood stream, and ova, which are released from the surface of the ovary in **ovulation**.

OVARIAN BURSA

Each ovary is pouched by the **ovarian bursa**.

LOCATION

The ovaries are paired glands usually found in the lumbar region of the abdominal cavity, a short distance caudal to the kidneys. These are almond-shaped.

LENGTH

The length of each ovary is about 1.5 cm.

DESCRIPTION

Each ovary presents for its description;

Two Surfaces

- i) Medial surface
- ii) Lateral surface

Both surfaces are rounded & smooth.

Two Borders

- i) Attached border
 - ii) Free border
- Two Extremities**
- i) Anterior extremity
 - ii) Posterior extremity

INTERNAL STRUCTURE

The ovary is invested in a dense connective tissue capsule, the *tunica albuginea*. The *medulla*, or central portion, of the ovary is the most vascular part, while the *cortex*, or outer portion, consists largely of dense, irregular connective tissue interspersed with follicles (developing ova) and interstitial cells, which have an endocrine function.

UTERINE TUBES

The **uterine tubes** (also called *oviducts*) are paired, flexuous and convoluted tubes that conduct the ova from each ovary to the respective horn of the uterus and are the usual site of fertilization of ova by the spermatozoa.

PARTS

- The uterine tube may be divided into three parts;
- i) **Infundibulum**; funnel-shaped part attached to the ovary.
 - ii) **Ampula**
 - iii) **Isthmus**: joins the uterine horn.

UTERUS

The **uterus** is a muscular hollow organ which is continuous with the uterine tube, anteriorly and opens into the vagina, posteriorly. It is Y-shaped and lies almost entirely within the abdominal cavity.

PARTS

- The uterus consists of three parts;
- i) Horns
 - ii) Body
 - iii) Neck

Horns

The anterior extremity joins uterine tube & posterior extremity unites with the uterine body. They taper gradually towards their free end.

Body

It is very smaller in size and is about 2 cm long.

Cervix or Neck

The cervix is the constricted posterior part of the uterus which projects caudally into the vagina.

The cervix is a heavy, smooth muscle sphincter that is tightly closed except during estrus and parturition. It presents two prominent features; i) **Internal oss** ii) **External oss**

INTERNAL STRUCTURE

The inner surface of the cervix is arranged in a series of circular ridges or rings, sometimes called *annular fold*.

REPRESENTATIVE VALUES FOR THE UTERUS	
Length of uterine horns	10 -12 cm
United parts of uterine horns	2.5 cm or more
Length of the uterine body	2 cm
Length of the cervix	About 4 cm

Uterine Glands

The mucosa lining the uterus, the **endometrium**, is a highly glandular tissue that varies in thickness and vascularity with hormonal changes in the ovary and with pregnancy.

The **uterine glands** are simple branched tubular glands that exhibit considerable coiling. These glands are particularly active during estrus and pregnancy, during which they produce a fluid colloquially known as **uterine milk**.

Caruncles

The **caruncles** are mushroom-like projections from the inner surface of the uteri; they provide a site of attachment for the fetal membranes.

VAGINA

The **vagina** is the portion of the reproductive tract that lies within the pelvis between the uterus cranially and the vulva caudally. The vagina is the birth canal for delivery of the fetus at parturition and a sheath (vagina is *Latin* for **sheath**) for the penis of the male during copulation.

LOCATION

The vagina lies entirely in the pelvic cavity. It is related dorsally to the rectum, ventrally to the urinary bladder and urethra.

LENGTH

The length of the vagina is about 8 cm.

FEATURES

The anterior part presents **fornix vaginae**, on each side of the cervix.

The posterior part is directly continuous with the vulva without any line of demarcation.

VESTIBULE & VULVA

Vestibule

The **vestibule** is the portion of the reproductive tract between the vagina and the external genitalia. The transition between vagina and vestibule is demarcated by the external urethral orifice, and therefore vestibule is functionally common to both urinary and reproductive tracts.

LENGTH

The vaginal vestibule is about 2.5 to 3.5 cm long.

Vulva

The vulva is the external genitalia of the female. It comprises **right** and **left labia**, which meet on the midline dorsally and ventrally at the **dorsal** and **ventral commissures**, respectively.

This segment of the genital tract is measured from the external urethral orifice to the ventral commissure.

The ventral commissure is usually somewhat pendulous and conceals the clitoris.

Clitoris

The **clitoris** is the homologue of the penis. It is a structure of erectile tissue that has the same embryonic origin as the penis in the male. Like the penis, the clitoris consists of two **crura** or roots, a **body** and a **glans**; only the glans is visible externally.

The clitoris is covered by stratified squamous epithelium and is well supplied with sensory nerve endings.

GROSS FEATURES

EXTERNAL URETHRAL ORIFICE: is present ant the anterior extremity of the ventral wall of vulva.

VALVULAR CLEFT: The External orifice of the vulva is known as valvular cleft,

LABIA VULVAE: The valvular cleft is margined by two prominent rounded lips labia vulva.

FEMALE URETHRA

The female urethra only serves for urination. It is narrower and much less dilatable.

LENGTH

The female urethra is about 5 to 6 cm in length.

RELATIONS

It is fused dorsally with the wall of vagina, while

Laterally and ventrally is covered by constrictor vestibular Muscle.

LIGAMENTS OF FEMALE GENITAL ORGANS

The ligaments suspend all the Internal Genitalia except the caudal part of the vagina to dorsal flanks.

TYPES OF LIGAMENTS

1) Broad Ligament of the Uterus

It is the extensive peritoneal fold on each side which attaches the genitalia.

It contains the vessels; *uterovarian* artery; (very prominent in this fold) veins and nerves.

PARTS

Each ligament may be divided into three parts.

i) **Mesovarian:** Fold of peritoneum attached with the ovary.

ii) **Mesosalpinx:** Fold of peritoneum that is attached with the uterine tube.

iii) **Mesometrium:** Fold of peritoneum attached with horns and body of uterus.

2) Proper Ligament of the Ovary

Each ovary is attached with cranial end of the uterine horn by proper ligament. It is short in form.

3) Round Ligament

It is the homologue of the embryonic gubernaculum, but is non functional in adult.

4) Inter-cornual Ligament

It is a small ligament which is present between the horns of the uterus.

GENITAL ORGANS WITH THEIR ATTACHED LIGAMENTS

Ovaries	Mesovarian, Proper ligament of the ovary, Round ligament
Horns of uterus	Mesometrium, Intercornual ligament, Proper ligament
Body of uterus	Mesometrium

MAMMARY GLANDS

The **mammary glands** are modified sudoriferous (sweat) glands that produce milk for the nourishment of offspring. In case of goat, there are two mammary glands which are relatively larger and approximately globular but flattened on septal side.

UDDER: In ruminants, individual glands are associated so closely to one another that they are commonly referred to as a single *udder*.

LOCATION

They are placed on either side of the median plane in the prepubic region.

COMPOSITION

Each gland is composed of a system of ducts connecting masses of secretory epithelium surrounded by connective tissue and fat and supported in a fibroelastic capsule. The proportion of secretory parenchyma to connective tissue is hormonally dictated; during lactation, the mammary gland's secretory tissue increase in volume. After the end of lactation, (when the dam is dry), the secretory tissues regress, and connective tissue constitutes a greater percentage of the gland.

STRUCTURE

The udders of the ewe and the doe differ from that of the cow in that each half of the udder has only one teat, one streak canal, one teat cistern, and one gland cistern. One half of the ovine (sheep) and caprine (goat) udder resembles one quarter of the bovine (cow) udder. The teat is sparsely covered with fine hair.

SUSPENSORY APPARATUS

The udder of lactating animal can weigh profoundly, so the organ is supported by a dense system of fibroelastic ligament called the *suspensory apparatus*. The primary supportive elements of the suspensory apparatus are its two *medial laminae*, which take their origin together from the linea alba of the abdominal wall and the symphysis of the pelvis.

COMPOSITION OF MILK

Milk contains all of the nutrients necessary for survival and initial growth of mammalian neonates. The nutrients in milk include sources of energy (lipids and carbohydrates), proteins to provide amino acids, vitamins, minerals (ash) for electrolytes, and water. The relative amounts of these nutrients in milk vary among species.

Species	Typical Values for Constituents of Milk in Grams per Liter				
	Lipids	Lactose	Protein	Ash (minerals)	Calcium
Cow	38	48	37	7.0	1.3
Mare	16	50	24	4.5	1.0
Ewe	70	40	60	8.0	1.9
Sow	80	46	58	8.5	2.0
Doe	40	45	35	7.8	1.2

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Chapter 13

NERVOUS SYSTEM

Outline

Division of Nervous System

Central Nervous System (CNS)

- Meninges
- Spinal cord
- Brain
 - Telencephalon
 - Diencephalon
 - Mesencephalon
 - Metencephalon
 - Myelencephalon
 - Ventricular system

Peripheral Nervous System (PNS)

- Cranial nerves
- Spinal nerves
 - Brachial plexus
 - Lumbo-sacral plexus

Cerebrospinal fluid (CSF)

Contents of vertebral canal

The nervous system is a complex mechanism by which the organism is brought into functional relation with its environment, and its various parts are coordinated.

DIVISION OF NERVOUS SYSTEM

For purpose of gross description, the entire nervous system is divided primarily into two parts: the **central nervous system (CNS)** and the **peripheral nervous system (PNS)**.

Central Nervous System comprises(a) the spinal cord, and (b) the brain.

Peripheral Nervous System includes (a) the cranial and spinal nerves with their ganglia, and (b) the sympathetic nervous system.

Central Nervous System (CNS)

MENINGES

The covering of spinal cord and brain are the meninges (singular meninx). They include three layers, from deep to superficial, the pia mater, the arachnoid, and the dura mater.

PIA MATER

The pia mater, the deepest of the meninges, is a delicate and very vascular membrane that invests the brain and spinal cord, following the grooves and depressions closely.

The pia mater forms a sheath around the blood vessels and follows them into the substance of the CNS.

ARACHNOID MATER

The arachnoid is a very delicate and transparent membrane which is situated between the dura and pia mater. Together, the pia mater and arachnoid constitute the *leptomeninges* (from the Latin word *lepto*; delicate), reflecting their fine, delicate nature.

SUBARACHNOID SPACE:The space between the two layers bridged by arachnoid trabeculae, is the subarachnoid space. It contains the cerebrospinal-fluid (CSF).

DURA MATER

The dura mater is a dense and tough fibrous outer covering of the CNS. Within the cranial vault, the dura mater is intimately attached to the inside of the cranial bones and so fulfills the role of periosteum. However, the dura mater of spinal meninges is separated from the periosteum of the vertebral canal by a fat-filled space, the *epidural space*.

It also forms the *falx cerebri*, a median sickle-shaped fold that lies in the longitudinal fissure and partially separates the cerebral hemispheres. Another fold of dura mater, the *tentorium cerebelli*, runs transversally between the cerebellum and the cerebrum.

SPINAL CORD

The spinal cord is the part of the central nervous system which is situated in the vertebral canal. It is the caudal continuation of the medulla oblongata. The cranial end of the spinal cord is continuous with the medulla oblongata of the brain at the level of the foramen magnum. Unlike the cerebrum, the spinal cord's gray matter is found at the center of the cord, forming a butterfly shape on cross section.

EXTERNAL FEATURES

Examination of cross sections of the spinal cord shows that it is a bilaterally symmetrical structure, incompletely divided into right and left halves by a ventral fissure and a dorsal septum.

Dorsal median sulcus: The spinal cord has this sulcus along its entire length.

Ventral median sulcus: On the ventral surface, ventral median sulcus runs along its entire length.

INTERNAL STRUCTURES

Basically, the spinal cord is made up of white and grey matter.

WHITE MATTER: It forms the dorsal column, ventral column and lateral columns.

GREY MATTER: It forms dorsal horn, ventral horn and the central canal.

DIVISION

According to the attachment of the spinal nerves, the spinal cord may be divided into five regions.

(i) Cervical (ii) Thoracic (iii) Lumbar (iv) Sacral and (v) Coccygeal

BRAIN

The brain is central part of the central nervous system that is situated in the cranial cavity.

The gross sub-divisions of the adult brain include;

- a) Cerebrum
- b) Cerebellum
- c) Brain stem

Dorsal view of Brain (See Figure 13- 1)

Ventral view of Brain (See Figure 13- 2)

Median section of Brain (See Figure 13- 3)

Telencephalon (End Brain)

The telencephalon, or end brain comprises two principal parts, the cerebral hemispheres and the optic part of the hypothalamus (rhinencephalon).

CEREBRAL HEMISPHERES

The cerebral hemispheres form the greater part of the fully developed brain. Viewed from above, they form an ovoid mass, of which the broader is posterior, and the greatest transverse diameter is a little behind the middle.

LONGITUDINAL FISSURE: The two hemispheres are separated by a deep median cleft, the longitudinal fissure of the cerebrum, which is occupied by a sickle-shaped fold of dura mater, the *falx cerebri*. **TRANSVERSE FISSURE:** The transverse fissure separates the hemisphere from the cerebellum, and contains the tentorium cerebelli.

EXTERNAL FEATURES

The surface area of the cerebrum is increased by numerous foldings to form convex ridges, called *gyri* (singular *gyrus*), which are separated by furrows called *fissures* or *sulci*. A particularly prominent fissure, the *longitudinal fissure*, lies on the median plane and separates the cerebrum into its right and left hemispheres.

INTERNAL STRUCTURE

Unlike the spinal cord, in the cerebrum the gray matter is on the exterior. This layer of cerebral grey matter is called *cerebral cortex*. It is the site at which voluntary movements are initiated, and higher functions, such as reasoning and planning, take place.

RHINENCEPHALON

The rhinencephalon or olfactory part of the brain comprises the olfactory bulb, tract and stria, the trigonum olfactorium, and the piriform lobe.

Olfactory bulb

The olfactory bulb is an oval enlargement which curves upward in front of the frontal pole of the hemisphere. Its convex face fits into the ethmoidal fossa and receives numerous olfactory nerve-fibers.

Olfactory tract

The olfactory tract is a very short but wide band of white substance which arises to the olfactory bulb and extends back to be continued by the olfactory stria. It contains a canal which connects the ventricle of the bulb with the lateral ventricle.

Olfactory stria

The olfactory striae are two in number. The lateral stria is much the largest and most distinct. It is clearly defined dorsally by the sulcus rhinalis and is marked off from the trigonum olfactorium by the sulcus arcuatus. The medial stria is smaller, short, and not so well-defined.

Trigonum olfactorium

The trigonum olfactorium is the prominent gray area situated in the angle of divergence of the medial and lateral olfactory striae. It is bounded laterally by the lateral olfactory stria, from which it is defined by the sulcus arcuatus.

Piriform lobe

The piriform lobe is the well-marked prominence on the base lateral to the optic tract and cerebral peduncle, from which it is separated by a deep fissure.

Diencephalon (Inter Brain)

The diencephalon or *inter-brain* comprises the thalamus and a number of other structures grouped about the third ventricle.

THALAMUS

The thalamus is the principal body in this part of the brain. It is an important relay center for nerve fibers connecting the *cerebral hemispheres* to the *brainstem* and *spinal cord*. It is a large, ovoid mass placed obliquely across the dorsal face of the each cerebral peduncle, so that the long axes of the two thalami would meet in front about at right angle.

PINEAL BODY

The pineal body (*epiphysis cerebri*) is a small ovoid or fusiform red brown mass situated in a deep central depression between the *thalami* and *corpora quadrigemina*.

MAMMILARY BODY

The mammillary body is a white, round elevation a little larger than a pea which projects ventrally at the anterior end of the median furrow of the interpeduncular fossa.

PITUITARY BODY

The pituitary body (*hypophysis cerebri*) is one of the most important endocrine glands. It was mentioned as covering part of the interpeduncular fossa. It is oval in outline, flattened dorso-ventrally. It is attached by a delicate tubular stalk, the *infundibulum*, to the *tuber cinereum*, a single gray prominence situated between the optic chiasm in front and the mammillary body behind.

OPTIC CHIASM AND TRACTS

The optic chiasm and tracts form the anterior boundary of the interpeduncular fossa. The *optic chiasm* is formed by the union of the both, right and left optic tracts. From the chiasm each *optic tract* curves obliquely around the cerebral peduncle to the posterior part of the thalamus.

Mesencephalon (Mid Brain)

The *mesencephalon* or *mid-brain*, lies between the diencephalon rostrally and the pons caudally. It consists of a dorsal part, the corpora quadrigemina, and a larger ventral part, the cerebral peduncles.

CORPORA QUADRIGEMINA

The corpora quadrigemina are four rounded eminences which lie under the posterior part of the *cerebral hemispheres*. They consist of two pairs, separated by a transverse groove. The anterior pair is larger and much higher than the posterior pair.

CEREBRAL PEDUNCLES

The cerebral peduncles appear on the base of the brain as two large, rope-like stalks which emerge from the pons close together and diverge as they pass forward to enter the cerebrum. These peduncles consist of both sensory and motor fiber tracts.

Metencephalon

The metencephalon includes the *cerebellum* dorsally and the *pons* ventrally.

CEREBELLUM

The cerebellum is situated in the posterior fossa of the cranium, and is separated from the cerebral hemispheres by the transverse fissure and the *tentorium cerebelli* which occupies it. It overlies the pons and the greater part of the medulla, from which it is separated by the fourth ventricle.

The cerebellum features two *lateral hemispheres* and a median ridge called the *vermis* because of its resemblance to a worm. The surface of the cerebellum consists of many laminae called *folia*. In the cerebellum, like the cerebrum, the white matter is central, and the gray matter is peripheral in the *cerebellar cortex*.

PONS

The pons is that part of the brainstem which lies between the medulla and the cerebral peduncles. Its surface possesses visible *transverse fibers* that form a bridge from one hemisphere of the cerebellum to the other.

Myelencephalon

The myelencephalon becomes the *medulla oblongata* in the adult.

MEDULLA OBLONGATA

The medulla oblongata (often simply called the medulla) is the cranial continuation of the *spinal cord*, from which it is arbitrarily distinguished at the *foramen magnum*. It lies on the basilar part of the *occipital bone*. The medulla oblongata contains a number of important autonomic centers and nuclei for cranial nerves.

Ventricular System

The internal cavities of the brain are referred as *ventricles* of the brain.

The ventricles are the remnants of the lumen of the *embryonic neural tube*.

There are four ventricles in the brain;

- i) **Two Lateral Ventricles:** Right and left ventricles lie within the respective cerebral hemispheres.
- ii) **Third Ventricle:** It is the internal brain cavity between the thalami. Most of the third ventricle is surrounded by the diencephalon.
- iii) **Fourth Ventricle:** It is situated between the cerebellum and the medulla oblongata.

COMMUNICATION

The *lateral ventricles* communicate with the midline third ventricle by way of the *interventricular foramina*.

The *third ventricle* connects with the fourth ventricle by way of the *cerebral aqueduct* passing through the midbrain.

The *fourth ventricle* communicates with the subarachnoid space surrounding the CNS through two *lateral apertures*.

Each ventricle features a *choroid plexus*, a tuft of blood capillaries that protrudes into the lumen of the ventricle. The plexus of capillaries is covered by a layer of ependymal cells that are continuous with the lining membranes of the ventricles.

Peripheral Nervous System

The PNS includes the cranial and spinal nerves with their ganglia, and the sympathetic nervous system. Its purpose is to convey sensory informations to the brain and spinal cord and to produce movements of muscle and secretion from glands via motor nerves.

CRANIAL NERVES

Classically, 12 pairs of cranial nerves arising from the basal surface of the brain are described. They are designated by Roman numerals, numbered from most rostral (I) to most caudal (XII).

<i>Number</i>	<i>Name</i>	<i>Type</i>	<i>Arises from</i>	<i>Distribution</i>
I	Olfactory	Sensory	Olfactory bulb	Olfactory mucosa
II	Optic	Sensory	Interbrain	Retina of the eye
III	Oculomotor	Motor	Midbrain	Extrinsic muscles of the eye.
IV	Trochlear	Motor	Midbrain	Obliquus dorsalis muscle.
V	Trigeminal	Mixed	Pons	Skin of face, Conjunctiva of eye and muscles of mastication.
VI	Abducens	Motor	Medulla	Rectus lateralis, Retractor bulbi muscles (of eye).
VII	Facial	Mixed	Medulla	Muscles of facial expression.
VIII	Vestibulochochlear	Sensory	Medulla	Semicircular canals and cochlea of the ear.
IX	Glossopharyngeal	Mixed	Medulla	Skin of internal auditory

X	Vagus	Mixed	Medulla	meatus and taste buds of the tongue. Skin of external auditory meatus.
XI	Accessory	Motor	Medulla	Trapezius and sternocephalicus muscles.
XII	Hypoglossal	Motor	Medulla	Muscles of the tongue.

SPINAL NERVES

The spinal nerves are arranged in pairs, of which there are usually thirty six (36) in case of Goat.

DISTRIBUTION

The spinal nerves are designated according to their relation to the vertebral column as;

No.	Name of Regional nerves	Number of nerve pairs
I	Cervical nerves	8
II	Thoracic nerves	13
III	Lumber nerves	6
IV	Sacral nerves	5
V	Coccygeal nerves	4

FORMATION

Dorsal and ventral roots arise from the spinal cord and fuse, generally close to the intervertebral foramen. At this point, the conjoined sensory fibers of the dorsal roots and motor fibers of the ventral root become the *spinal nerve*, which is characterized as a *mixed nerve*.

BRANCHES

As soon as the spinal nerve emerges through the intervertebral foramen, it divides into two branches;

- (i) Dorsal branch (ii) Ventral branch

INNERVATION

The spinal nerves tend to innervate the region of the body in the area adjacent to where they emerge. The limbs, however, are supplied with sensory and motor fibers within tangled arrangement of spinal nerves known as *plexuses*. Here, only two important plexuses of the limbs; brachial plexus of thoracic limb and the lumbo-sacral plexus of hind limb are described.

Brachial Plexus

Each thoracic limb is supplied by a *brachial plexus*.

FORMATION

The brachial plexus is a network of nerves derived from the ventral branches of the *last three cervical* and *first thoracic* nerves.

BRANCHES

The brachial plexus gives rise to specific named nerves that innervate the muscles of the thoracic limb. The branches arising from this plexus are described below with the muscles supplied by each.

Nerve	Muscles Innervated
Suprascapular	Supraspinatus & infraspinatus

Subscapular	Subscapularis
Thoracodorsal	Latissimus dorsi
Long thoracic	Serratus ventralis
Pectoral	Superficial, deep pectoral
Musculocutaneous	Biceps brachii, Coracobrachialis, Brachialis
Axillary	Teres major et minor, Deltoideus
Radial	
<i>Superficial branch</i>	Triceps brachii, Anconeus
<i>Deep branch</i>	Extensor carpi radialis, Common & lateral digit. extensors, Ulnaris lateralis
Ulnar	Flexor carpi ulnaris, Deep digital flexor
Median	Pronator teres, Flexor carpi radialis, Superficial and deep digital flexor.

Lumbosacral Plexus

The right and left lumbosacral plexuses supply nerves to the respective pelvic limbs.

FORMATION

The lumbosacral plexuses are made up of the ventral branches of the last few lumbar and first two sacral nerves.

BRANCHES

The nerves derived from the lumbosacral plexus are described below in the table.

Nerve	Muscles Innervated
Cranial gluteal	Middle and deep gluteal, Tensor fascia latae
Cudal gluteal	Parts of middle gluteal, Semitendinosus
Femoral	Sartorius, Quadriceps femoris, iliopsoas
Obturator	Adductor, Gracilis, Pectineus, Obturator externus
Sciatic	Semitendinosus, Semimembranosus, Biceps femoris, Quadratus femoris, Obturator internus
Peroneal	Cranial tibial, Long and lateral digital extensor, Proneus (longus & tertius)
Tibial	Gastrocnemius, Deep digital flexor, Popliteus

CEREBROSPINAL FLUID (CSF)

The *cerebrospinal fluid (CSF)* is a modified tissue fluid. It is contained in the ventricular system of the brain and in the subarachnoid space around the brain and spinal cord. CSF replaces lymph in the CNS.

FORMATION

1. The bulk of the CSF is formed by the choroid plexuses of the lateral ventricles, and lesser amounts by the choroid plexuses of the third and fourth ventricles.
2. Possibly it is also formed by the capillaries on the surface of the brain and spinal cord.

CIRCULATION

The circulation of cerebrospinal fluid beings in the two lateral ventricles (where majority is produced), flows through the *interventricular foramina* into the third ventricle, then by way of the *cerebral aqueduct* into the fourth ventricle, and finally through the lateral apertures into the *subarachnoid space*, where it surrounds the brain and spinal cord.

ABSORPTION

1. CSF is absorbed chiefly through the arachnoid villi and granulations.
2. It is also absorbed partially by the perineural lymphatics around the few cranial nerves.
3. It is also absorbed by veins related to spinal nerves.

FUNCTIONS

It is (a) protective, (b) nutritive, and (c) a pathway for excretion from the central nervous system (CNS).

NEURON

Neurons are the basic building blocks of the nervous system. These specialized cells are the information-processing units of the brain responsible for receiving and transmitting information. Each part of the neuron plays a role in the communication of information throughout the body.

STRUCTURE OF A TYPICAL NEURON (See Figure 13 – 4)

Dendrites: Dendrites are treelike extensions at the beginning of a neuron that help increase the surface area of the cell body and are covered with synapses. These tiny protrusions receive infor-mation from other neurons and transmit electrical stimulation to the soma.

CONTENTS OF THE VERTEBRAL CANAL

..... (See Figure 13 – 5)

The vertebral canal contains the following structures from without inwards.

1. Epidural space
2. Thick dura mater
3. Subdural capillary space.
4. Delicate arachnoid mater
5. Wide subarachnoid space (containing CSF)
6. Firm pia mater (the arachnoid and pia together form the leptomeninges).
7. Spinal cord and the cauda equina.

Epidural Space

It lies between the spinal dura mater, and the periosteum and ligaments lining the vertebral canal.

Spinal Dura Mater

It is a thick, tough fibrous membrane which forms a loose sheath around the spinal cord.

Subdural Space

It is a capillary (potential) space between the dura and the arachnoid, containg a thin film of serous fluid.

Arachnoid Mater

This is a thin, delicate and transparent membrane that loosely invests the entire central nervous system.

Subarachnoid Space

It is a wide space between the pia and the arachnoid, filled with cerebrospinal fluid (CSF). It surrounds the brain and spinal cord like a water cushion.

Spinal Pia Mater

The spinal pia is a thicker, firmer, and less vascular than the cerebral pia.

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ENDOCRINE SYSTEM

Outline

- **Hormones**
- **Response of a hormone**
- **Endocrine Glands, location and their hormones**
 - Hypothalamus
 - Pituitary gland
 - Pineal gland
 - Thyroid gland
 - Parathyroid gland
 - Thymus gland
 - Adrenal glands
 - Pancreas
 - Liver
 - Kidneys
 - Heart
 - Testes
 - Ovaries

In order to survive, animals must constantly adapt to changes in the environment. The *nervous* and *endocrine* systems both work together to bring about this adaptation. In general the nervous system responds rapidly to short-term changes by sending electrical impulses along nerves and the endocrine system brings about longer-term adaptations by sending out chemical messengers called *hormones* into the blood stream.

The classic *endocrine system* consists of a group of ductless glands that secrete hormones. Unlike exocrine glands, endocrine glands have no ducts, but release their secretions directly into the blood system, which carries them throughout the body.

Hormones

Hormones are chemical messengers that are secreted by endocrine glands and function in extremely small concentration.

Response of a hormone

A nerve impulse travels rapidly and produces an almost instantaneous response but one that lasts only briefly. In contrast, hormones act more slowly and their effects may be long lasting. Target cells respond to minute quantities of hormones and the concentration in the blood is always extremely low.

ENDOCRINE GLANDS

The major glands of the endocrine system are:

1. Hypothalamus
2. Pituitary gland
3. Pineal gland
4. Thyroid gland
5. Parathyroid glands
6. Thymus gland
7. Adrenal glands

8. Pancreas
9. Liver
10. Kidneys
11. Heart
12. Testes
13. Ovaries

1. HYPOTHALAMUS

The hypothalamus secretes hormones that stimulate or suppress the release of hormones in the pituitary gland, in addition to controlling water balance, sleep, temperature, appetite, and blood pressure.

LOCATION

The hypothalamus is located in the brain, at the base of the optic chiasm. This small but vital region of the brain lies just above the pituitary and provides the link between the nervous and endocrine systems.

Secreted hormone	From cells	Effect
Thyrotropin-releasing hormone (TRH)	Parvocellular neurosecretory neurons	Release thyroid-stimulating hormone from anterior pituitary. Stimulate prolactin release from anterior pituitary
Gonadotropin-releasing hormone (GnRH)	Neuroendocrine cells of preoptic area	Release of FSH and LH from anterior pituitary
Growth hormone-releasing hormone (GHRH)	Neuroendocrine cells of arcuate nucleus	Release growth hormone from anterior pituitary
Corticotropin-releasing hormone (CRH)	Parvocellular neurosecretory neurons	Release ACTH from anterior pituitary
Growth hormone-inhibiting hormone (GHIH) or somatostatin	Neuroendocrine cells of Periventricular nucleus	Inhibit release of GH and TSH from anterior pituitary
Prolactin inhibiting factor (PIF) or Dopamine	Dopamine neurons of arcuate nucleus	Inhibit release of prolactin and TSH from anterior pituitary
Prolactin-releasing hormone (PRH)	---	Release prolactin from anterior pituitary

2. PITUITARY GLAND (Hypophysis)

The pituitary gland is often called the “master” endocrine gland because it controls many of the other endocrine glands in the body.

LOCATION

The pituitary gland is a pea-sized structure that is attached by a stalk, the infundibulum, to the underside of the cerebrum of the brain

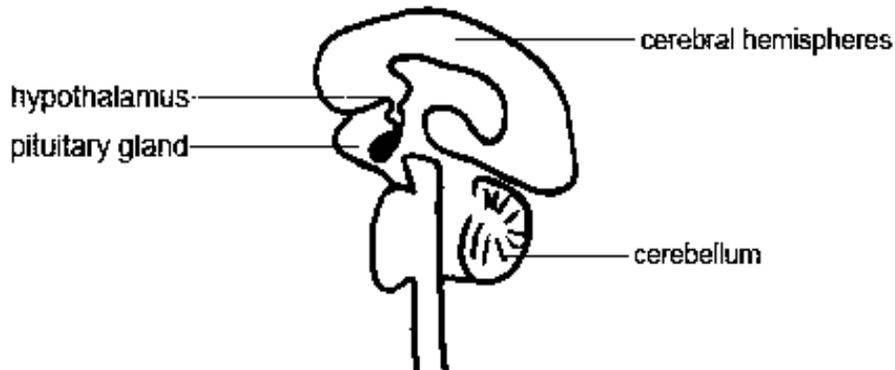


Figure 14.1: Position of Pituitary gland and Hypothalamus

DIVISION

The pituitary gland is divided into three lobes with different functions;

- (i) Anterior pituitary (*Adenohypophysis*)
- (ii) Posterior pituitary (*Neurohypophysis*)
- (iii) Intermediate pituitary (*Pars intermedia*)

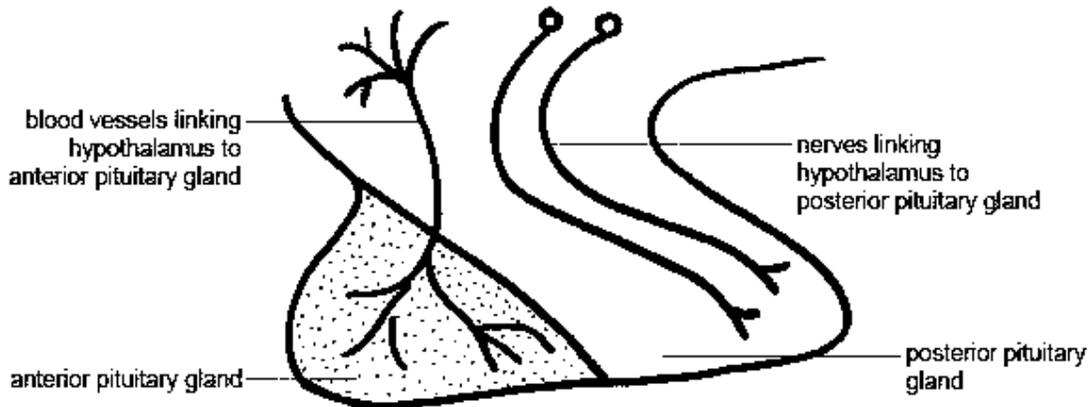


Figure 14.2: Lobes of Pituitary Gland

Anterior Pituitary Lobe (Adenohypophysis)

The anterior pituitary lobe secretes hormones that regulate a wide range of activities in the body.

Secreted hormone	From cells	Effect
Growth hormone (GH)	Somatotropes	Stimulates growth and cell reproduction Release Insulin-like growth factor (IGF) from liver
Prolactin (PRL)	Lactotrophes	Milk production in mammary glands Sexual gratification after sexual act
Adreno-corticotrophic hormone (ACTH)	Corticotropes	Synthesis of corticosteroids in adrenocortical cells
Thyroid-stimulating hormone (TSH)	Thyrotropes	Stimulates thyroid gland to secrete its hormones
Follicle-stimulating hormone (FSH)	Gonadotropes	In female: stimulates maturation of Graafian follicles In male: Spermatogenesis, enhancing prod. of

		ABP.
Luteinizing hormone (LH)	Gonadotropes	In female: ovulation In male: stimulates leydig cell production of T4.

Posterior Pituitary Lobe (Neurohypophysis)

The hormones of the posterior pituitary lobe are not secreted in this lobe, merely stored.

Secreted hormone	From cells	Effect
Oxytocin	Magnocellular neurosecretory cells	Contraction of cervix and vagina Release milk from milk glands, Involved in orgasm, trust between people. and circadian homeostasis.
Antidiuretic hormone (ADH) or Vesopressin	Magnocellular neurosecretory cells	Retention of water in the kidneys Moderate vasoconstriction

Intermediate Pituitary Lobe (Pars intermedia)

Secreted hormone	From cells	Effect
Melanocyte-stimulating hormone (MSH)	Melanotroph	Melanogenesis by melanocytes in skin and hair

3. PINEAL GLAND (Epiphysis)

The pineal is a small ovoid or fusiform mass which is found deep within the brain. It is sometimes known as the 'third eye' as it responds to light and day length.

LOCATION

The pineal gland (epiphysis) is situated in a central depression between the thalami (sing. thalamus) and corpora quadrigemina (also called colliculi).

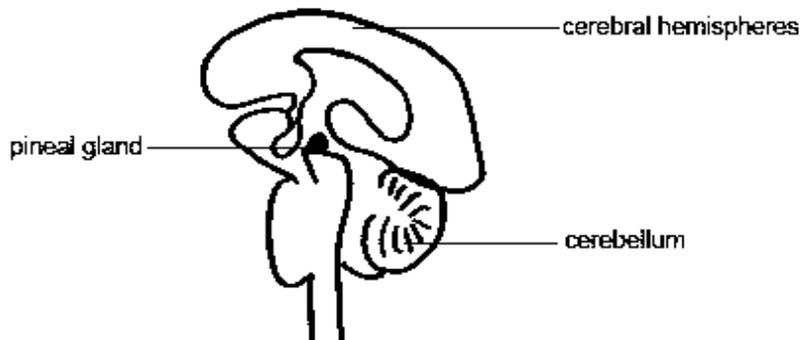


Figure 14.3: Position of Pineal gland

Secreted hormone	From cells	Effect
Melatonin	Pinealocytes	Influences the development of sexual maturity and the seasonality of breeding and hibernation.

4. THYROID GLAND

The thyroid is a very vascular ductless gland, firm in texture and dark red-brown in color.

LOCATION

It is situated below the larynx (voice box), on the anterior part of the trachea, to which it is loosely attached.

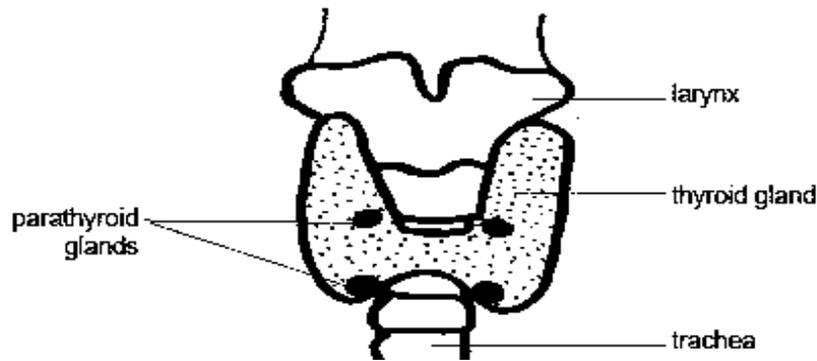


Figure 14.4: The Thyroid and Parathyroid Glands

SECRETED HORMONE

Secreted hormone	From cells	Effect
Triiodothyronine (T3)	Thyroid epithelial cell	Potent form of thyroid hormone; Increase the basal metabolic rate. Affect protein synthesis
Tetraiodothyroxine (T4)	Thyroid epithelial cells	Less active form of thyroid hormone; increase the basal metabolic rate. Often functions as a prohormone
Calcitonin	Parafollicular cells	Construct bone Reduce blood Ca ⁺

5. PARATHYROID GLAND

The parathyroid are pale in color and not so dense as thyroid.

LOCATION

They are small glandular bodies found in the thyroid gland.

SECRETED HORMONE

Secreted hormone	From cells	Effect
Parathyroid hormone (PTH)	Parathyroid chief cell	Increase blood Ca ⁺ - Ca ⁺ reabsorption in kidney - activate vitamin D (Slightly) decrease blood phosphate:

6. THYMUS GLAND

The thymus is a ductless gland which has close resemblance to the lymphoid tissue.

LOCATION

It is situated in the anterior mediastinal space of the thoracic cavity.

FUNCTION

The main function of the thymus is to provide an area for [T lymphocyte](#) maturation, and is vital in protecting against [autoimmunity](#).

The stock of T-lymphocytes is built up in early life, so the function of the thymus is diminished in adults. It is largely degenerated in elderly adults

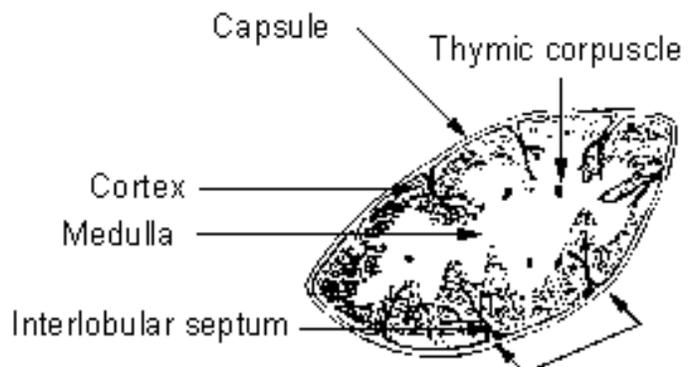


Figure 14.5: Internal Structure of Thymus

and is barely identifiable, consisting mostly of fatty tissue; however it continues to function as an [endocrine gland](#) important in stimulating the immune system.

7. ADRENAL GLANDS

The adrenal glands are two small, bean-shaped organs.

LOCATION

The right adrenal gland lies along the anterior part of the medial border of the kidney, at the angle of the junction of the right renal vein & caudal vena cava. The left one is usually longer, flatter and somewhat bent.

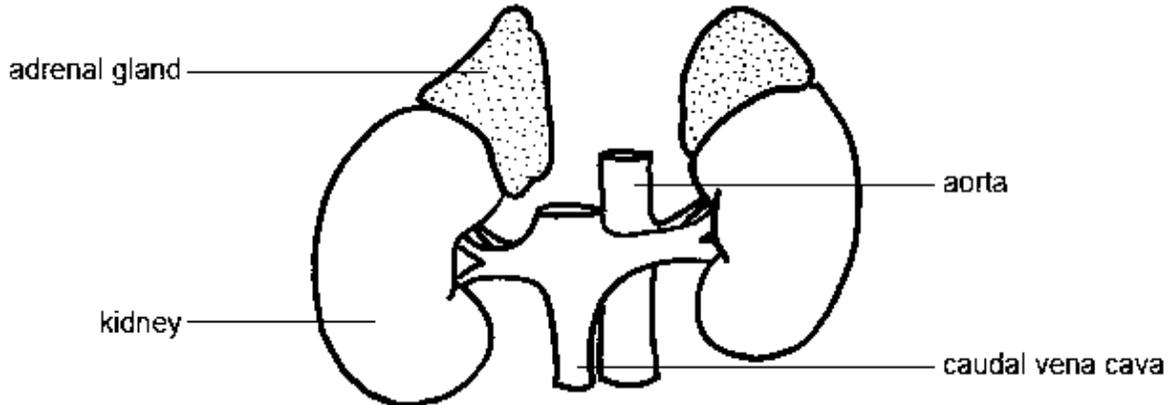


Figure 14.6 : The Adrenal Glands

STRUCTURE

Each adrenal body presents two differential parts;

- (i) An outer *cortex*
- (ii) An inner *medulla*

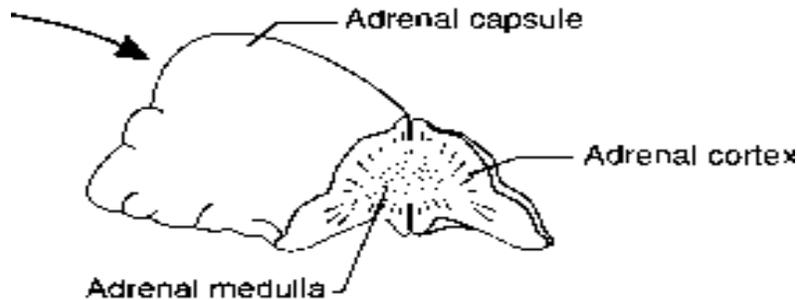


Figure 14.7 : Internal Structure of an Adrenal Gland

Secreted hormone	From cells	Effect
Glucocorticoids (chiefly) Cortisol	Zona fasciculata & zona reticularis	Stimulation of gluconeogenesis Inflammatory and immunosuppressive
Mineralocorticoids (chiefly) Aldosterone	Zona glomerulosa	Increase blood volume by reabsorption of Na ⁺ in kidney Potassium and H ⁺ secretion in kidney
Androgens (include Testosterone)	Zona fasciculata and zona reticularis	Virilization Anabolic

(ii) Adrenal Medulla

Secreted hormone	From cells	Effect
Adrenaline (epinephrine)	Chromaffin cells	Fight-or-flight response - Boost the supply of oxygen and glucose to brain and muscles (by increasing heart rate, vasodilation, increasing catalysis of glycogen in liver, breakdown of lipids in fat cells) - Dilate the pupils - Suppress non-emergency bodily process (e.g. digestion) - Suppress immune system
Noradrenaline (norepinephrine)	Chromaffin cells	Fight or flight response - Boost the supply of oxygen and glucose to brain and muscles (by increasing heart rate, vasoconstriction, increased blood pressure, breakdown of lipids in fat cells) - Increase skeletal muscle readiness.

8. PANCREAS

The pancreas is an oblong, pinkish organ that lies in the first bend of the small intestine

LOCATION

The pancreas lies entirely to the right of the median plane.

It mostly lies on the visceral surface of the liver and attached with the duodenum.

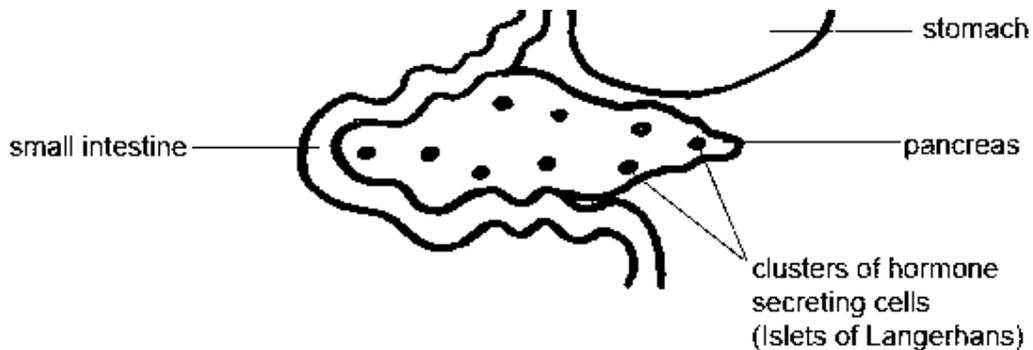


Figure 14.8 : The Pancreas

Secreted hormone	From cells	Effect
Insulin	β islets cells	Intake of glucose, glycogenesis and glycolysis in the liver and muscle from blood Intake of lipid and synthesis of triglycerides in adipocytes
Glucagon	α islets cells	Glycogenolysis and gluconeogenesis in liver Increase blood glucose level
Somatostatin	δ Islets cells	Inhibit release of insulin Inhibit release of glucagon. Suppress exocrine secretory action

9. LIVER

The liver is the largest gland of the body, constituting 1-2 % of total adult body weight.

LOCATION

The liver is always located immediately caudal to the diaphragm (in contact with it) and tends to be located on the right side as the reticulorumen pushes everything else to the right.

Secreted hormone	From cells	Effect
Insulin-like growth factor (IGF)	Hepatocytes	Insulin-like effects Regulate cell growth and development
Angiotensinogen and angiotensin	Hepatocytes	Vasoconstriction Release of aldosterone from adrenal cortex.

10. KIDNEYS

The kidneys are a pair of excretory organs situated in the dorsal part of the abdominal cavity on each side of the aorta and caudal vena cava, just ventral to the first few lumbar vertebrae.

LOCATION

The kidneys usually lie ventral to the first three lumbar transverse processes; against the dorsal wall of the abdominal cavity.

Secreted hormone	From cells	Effect
Renin	Juxtaglomerular cells	Activate the renin-angiotensin system by producing angiotensin I of angiotensinogen
Erythropoietin (EPO)	Extraglomerular mesangial cells	Stimulates erythrocyte production
Calcitriol (1,25-dihydroxycholecalciferol)	---	Active form of Vitamin D3 Increase intestinal absorption of calcium, inhibit release of PTH
Thrombopoietin	---	Stimulates megakaryotes to produce platelets

11. HEART

The heart is a conical hollow muscular organ that pumps blood to various parts of the body to meet their nutritive requirements.

LOCATION

The heart is situated in the middle mediastinum and is enclosed within the pericardium.

Secreted hormone	From cells	Effect
Atrial-natriuretic peptide (ANP)	Cardiac myocytes	Reduce blood pressure Increase Na ⁺ excretion by kidneys
Brain-natriuretic peptide (BNP)	Cardiac myocytes	Reduce blood pressure (to a minor degree than ANP)

12. TESTES

The testes (testicles) are the male gonads. They are homologous with the ovary of the female. The spermatic cord suspends each individual testis within the scrotum.

LOCATION

The testicles are held near to the sigmoid (S-shaped) flexure of the penis.

Secreted hormone	From cells	Effect
Androgens (chiefly Testosterone)	Leydig cells	<i>Virilizing:</i> • maturation of male sex organs and development of male secondary sex characteristics. • Deepening of voice <i>Anabolic:</i> • growth of muscle mass and strength,

		increase bone density, growth and strength.
Estradiol	Sertoli cells	Prevent apoptosis of germ cells
Inhibin	Sertoli cells	Inhibit production of FSH

13. OVARIES

The ovaries, like the testes in the male, are the primary organs of reproduction in the female.

LOCATION

The ovaries are paired glands usually found in the lumbar region of the abdominal cavity, a short distance caudal to the kidneys. These are almond-shaped.

Progesterone	Granulosa cells, theca cells	<p>Support pregnancy:</p> <ul style="list-style-type: none"> • Convert endometrium to secretory stage • Make cervical mucous permeable to sperm • Inhibit immune response • Decrease uterine smooth muscle contractility • Inhibit lactation and onset of labor <p>Other:</p> <ul style="list-style-type: none"> • Raise epidermal growth factor-I levels • Increase core temperature during ovulation • Reduce spasm and relax smooth muscles. <p>Anti-inflammatory:</p> <ul style="list-style-type: none"> • Reduce gall-bladder activity • Normalize blood clotting and vascular tone, cell O2 levels. • Increase resilience in bone, teeth, gums, joints, tendon, ligament, and skin. • Promote healing by regulating collagen • Provide nerve function and healing by regulating myelin • Prevent endometrial cancer by regulating effects of estrogen
Estrogens (chiefly estradiol)	Granulosa cells	<p>Structural:</p> <ul style="list-style-type: none"> • Promote formation of female secondary sex characteristics • Reduce muscle mass • Stimulate endometrial growth • Increase uterine growth • Reduce bone resorption and increase bone formation <p>Protein synthesis:</p> <ul style="list-style-type: none"> • Increase hepatic production of binding proteins <p>Coagulation:</p> <ul style="list-style-type: none"> • Increase circulating level of blood clotting factors. • Increase platelet adhesiveness • Increase HDL, triglycerides • Decrease LDL, fat deposition <p>Fluid balance:</p> <ul style="list-style-type: none"> • Regulate salt and water retention • Increase growth hormone <p>Gastrointestinal tract:</p> <ul style="list-style-type: none"> • Reduce bowel motility • Increase cholesterol in bile <p>Melanin:</p> <ul style="list-style-type: none"> • Increase pheomelanin, reduce eumelanin

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ORGAN OF VISION---THE EYE

Outline

Orbit

Periorbita

Eyelids

- Upper and lower
- Third

Conjunctiva

- Palpebral
- Bulbar

Eyeball

Layers of Eyeball

- Fibrous tunic
 - Sclera
 - Cornea
- Vascular tunic
 - Choroid
 - Ciliary body
 - Iris
- Nervous tunic
 - Retina

Extraocular Muscles

Tarsal glands

Gland of third eyelid

Lacrimal Apparatus

- Lacrimal gland

The eye is an elaborate organ whose primary function is to collect and focus light upon the photosensitive retina.

SITUATION

It lies within a cone-shaped cavity of the skull, the *orbit*, which houses the *eyeball* (globe) and a number of other soft tissue structures, the *ocular adnexa* (e.g. muscles, glands).

COMPONENTS

The eye or organ of vision consists of;

- (i) Eyeball
- (ii) Optic Nerve
- (iii) Accessory organs.

Orbit

The orbit is a conical cavity containing the eyeball and the ocular adnexa.

The orbit is formed by the frontal, lacrimal and the zygomatic bones of the face.

Periorbita

The periorbita is a cone shaped sheath of connective tissue that surrounds the eyeball and its muscles, nerves and vessels.

Eyelids

Upper and Lower

The eyelids (palpebrae), *upper* and *lower*, are two mobile folds of haired skin protect the anterior aspect of the eyeball. **PALPEBRAL FISSURE:** the interval between the margins of the two palpebrae is the palpebral fissure. The ends of the fissure are the angles or canthi of an eye. i.e. (i) Medial canthus (ii) Lateral canthus

Third

The third eyelid, or *nictitating membrane* is a fold of the mucous membrane arising from the ventromedial aspect of the conjunctival sac between the eyeball and eyelids (palpebrae). It is given rigidity by a T-shaped cartilage, and it smoothes the tear film and protects the cornea.

Conjunctiva

The conjunctiva is the mucous membrane that lines the eyelids and anterior part of the eyeball (globe). **Conjunctival Sac:** It is a very small space between the eyelids and the surface of the eye.

DISTRIBUTION

(a) Palpebral conjunctiva

It is the part of conjunctiva that is in contact with or lines the eyelids (palpebrae).

(b) Bulbar conjunctiva

It is that part of conjunctiva which is reflected upon the anterior part of the eyeball (globe).

Eyeball

The eyeball (globe) is situated in the anterior part of the orbital cavity. It is protected in front by the eyelids and conjunctiva.

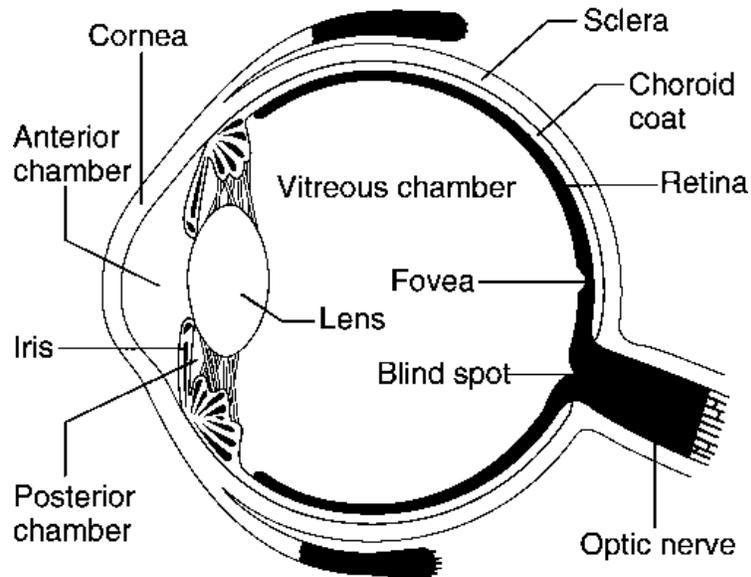


Figure 15 -1: Structure of Eyeball (Globe)

Layers of the Eyeball

The eyeball comprises three concentric layers which are also named coats or tunics of the eyeball.

These three layers (tunics) are named; (i) the fibrous tunic, (ii) the vascular tunic, and (iii) the nervous tunic.

FIBROUS TUNIC

The outer *fibrous tunic* of the eyeball is made up of a posterior opaque *sclera* and an anterior transparent *cornea*.

Sclera

The sclera is white, variably tinged gray or blue; it meets the clear cornea at a transitional region called the *limbus*. It is in general white, but may have a bluish tinge in its thinnest part. The tough sclera is the site of insertion for the extraocular eye muscles.

Cornea

The cornea is the transparent anterior part of the fibrous tunic. It is the most powerful reflecting layer of the eye.

VASCULAR TUNIC

The middle tunic of the eyeball, the *vascular tunic*, is composed of three parts; choroid, ciliary body and iris.

Choroid

The vascular tunic in the posterior portion is the choroid. It is highly vascular and possesses multiple layers. The deepest of these is the *tapetum*. The tapetum is confined to the dorsal part of the posterior globe. The ventral portion of the choroid is usually not reflective.

Ciliary body

The ciliary body is the anterior continuation of the vascular tunic. It is a circumferential thickening of the vascular tunic, and it gives rise to many fine *suspensory ligaments* that support the lens.

Iris

The iris is the most anterior portion of this tunic and the only part of the vascular tunic normally visible in the living animal. It consists of a pigmented ring of tissue, perforated in its center by the *pupil*. The iris divides the aqueous filled *anterior* segment of the eye into *anterior* and *posterior chambers*.

NERVOUS TUNIC

The deepest layer of the eyeball is the *nervous tunic* or *retina*.

Extraocular Muscles

The globe of the eye moves by the action of seven striated muscles, designated *extraocular muscles* to distinguish them from the intraocular muscles that lie entirely within the eyeball.

Muscle Type	Name of Muscle
Four straight muscles	Rectus dorsalis, Rectus ventralis Rectus medialis, Rectus lateralis
Two oblique muscles	Obliquus dorsalis, Obliquus ventralis
One retractor muscle	Retractor bulbi or oculi

Tarsal Glands

Abundant modified sweat and sebaceous glands are associated with the lid margin. A row of large modified sebaceous glands, the tarsal glands, is specially of great importance.

LOCATION

The tarsal glands are present in both palpebrae and open into a shallow furrow near the muco-cutaneous junction of the eyelid.

APPEARANCE

The glands are visible as yellowish-white columns under the mucous membranes on the inner surface of lid.

PRODUCTION

The tarsal glands produce an important oil layer of the tear film.

Gland of Third Eyelid

The third eyelid (nictitating membrane) has at its base a serous gland, called simply the gland of the third eyelid.

SECRETION

It normally contributes about 50% of the tear film.

Lacrimal Apparatus

The Lacrimal apparatus comprises a series of serous, seromucous and mucous glands and the duct system that drain their secretions.

FUNCTION

This apparatus provides a moist environment for the anterior surface of the eye.

Lacrimal Gland

The Lacrimal gland lies in the dorso-lateral portion of the orbit.

SECRETION

The secretion of lacrimal gland, together with that of the gland of third eyelid, is the major contributor to the tear film.

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